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Proceedings of a Maritimes Regional Peer Review of the 2012 Framework and Assessment for 4VWX Silver Hake

Part 1: May 30-31, 2012
Part 2: November 15-16, 2012
Part 3: December 11, 2012
Dartmouth, Nova Scotia

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A Maritimes Regional Science Peer Review Process to review the assessment framework for, and then assess the status of, 4VWX silver hake was conducted in 2012 at the Bedford Institute of Oceanography, Nova Scotia in three parts: a review of data inputs (May 30-31, 2012), a review of candidate population models (November 15-16, 2012), and the assessment (December 11, 2012). Participants included DFO Science and Resource Management, an external reviewer from the Northeast Fisheries Science Center, Woods Hole, Massachusetts, provincial fisheries management, and fishing industry representatives. The results of these meetings will be used to support management decisions related to the 4VWX silver hake fishery in 2013 and beyond.

Compte rendu de l'examen régional par les pairs du cadre et de l'évaluation pour le merlu argenté des divisions 4VWX de 2012 de la région des Maritimes; Partie 1 : 30 au 31 mai 2012, Partie 2 : 15 au 16 novembre 2012, Partie 3 : 11 décembre 2012.

SOMMAIRE

Un processus régional d'examen scientifique par les pairs de la région des Maritimes pour examiner le cadre d'évaluation et évaluer la situation du merlu argenté des divisions 4VWX a été mené en 2012 à l'Institut océanographique de Bedford, en Nouvelle-Écosse, en trois parties : un examen de la saisie de données (les 30 et 31 mai 2012), un examen des modèles de population candidats (les 15 et 16 novembre 2012) et l'évaluation (le 11 décembre 2012). Les participants comprenaient des représentants du Secteur des sciences et de la Gestion des ressources de Pêches et Océans Canada, un examinateur externe du Northeast Fisheries Science Center à Woods Hole (Massachusetts) et des représentants de la gestion des pêches provinciales et de l'industrie de la pêche. Les résultats de ces réunions serviront à appuyer les décisions de gestion concernant la pêche du merlu argenté des divisions 4VWX en 2013 et au cours des années suivantes.

PART 1: DATA INPUTS (MAY 30-31, 2012)

INTRODUCTION

The chair of the meeting, T. Worcester, Coordinator for the Centre for Science Advice in the Maritimes Region, welcomed everyone and thanked them for coming to this DFO Science Peer Review of the Framework and Assessment for 4VWX Silver Hake.

Since 1993, silver hake has been assessed 5 times (1998, 1999, 2003, 2005, and 2009). In 1998, there was concern about the large retrospective pattern observed in the population model (a Virtual Population Analysis (VPA) model), and the VPA model was rejected in 1999. No model has been used to provide advice on the fishery since that time. The subsequent assessments have been based on fishery, survey, and other indices. At the 2009 assessment, it was suggested that a review of the assessment framework was in order. A request to initiate a framework review for silver hake was submitted to the Centre for Science Advice in 2011.

As described in the Terms of Reference (Appendix 1), the review of the framework was expected to take several meetings to complete. This first meeting was to review the data sources available for use in the development of the assessment, as well as the methods used to collect and analyze that data.

The DFO Science peer-review process is meant to be an open, transparent, and inclusive process, so participants (Appendix 2a) were encouraged to ask questions of clarifications and to participate actively in the discussion. It was explained that the meetings would operate by consensus, where possible.

The Agenda (Appendix 3a) was reviewed, and nothing further was added.

MANAGEMENT UNIT / STOCK STRUCTURE

Working Paper: Silver Hake Framework Assessment. CSA Working Paper 2012/042.

M. Showell

Presentation Highlights

The management unit for silver hake being reviewed in this assessment framework includes Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX. In recent assessments, survey trends in terms of abundance and biomass have been calculated for the Scotian Shelf portion of 4VWX only, excluding the Bay of Fundy (DFO summer research vessel strata 484 through 495), as silver hake found in the Bay of Fundy area are thought to represent a portion of the Gulf of Maine/Northern Georges Bank silver hake stock rather than the Scotian Shelf stock.

Efforts to resolve questions of stock structure of silver hake in this area have provided contradictory results. There have been investigations of blood proteins in silver hake by US scientists (Machado-Schiaffino et al. 2011). There has also been genetic analysis of DNA at 7 alleles (Phoel et al. 2001) that indicated Bay of Fundy plus the Gulf of Maine was one stock. No recent work on silver hake stock structure has been done in Canada.

The 4VWX management unit for silver hake was originally established based on the perception of discontinuities in distribution. However, in 1999, attempts to resolve the retrospective problem in the VPA by looking at the ECMSAT (Canada/US combined research survey database) did not indicate a discontinuity between the Scotian Shelf and the Bay of Fundy.

Survey trends between the two areas have also been investigated in the past. When abundance was high in the Gulf of Maine, it tended to be high in the Bay of Fundy, but there

was no correspondence with the Scotian Shelf. Also, in the past, removal of Bay of Fundy strata tended to improve tracking of age classes.

Discussion

Evidence for two separate stocks on the Scotian Shelf was discussed. Some time ago, D. Waldron looked at meristics/morphometrics of silver hake on the Scotian Shelf for his thesis. He found significant differences between the inshore and offshore. This made him wonder whether there might be a secondary stock. Given the migratory nature of silver hake, however, this was not expected. While he wrote a paper on his findings, it does not appear to have been used by NAFO to change the management area. These results may not have been accepted by NAFO.

A question was asked about the genetics work that had been done on silver hake, specifically whether it had been published. It may only have been published as a US National Marine Fisheries Service (NMFS) report, but efforts to contact W. Phoel to find out had not been successful. It was noted that this genetics work may not help with regional stock definition.

There was some discussion about the relative biomass between the Scotian Shelf, Bay of Fundy, and the Gulf of Maine/northern Georges Bank. The US biomass appears to be much larger than the Canadian biomass, and the Scotian Shelf biomass appears to be larger than the Bay of Fundy (about double). The US fishery is about 7,700 t (NEFSC 2010). Historically, it was a lot larger. The US fishery shows a similar trend to the Canadian fishery.

In the DFO summer Research Vessel (RV) survey trends reports (e.g., DFO 2012), different survey strata are used to plot trends for silver hake (Eastern Scotian Shelf, Western Scotian Shelf, and the Bay of Fundy). This report shows different trends in the Western Scotian Shelf and the Bay of Fundy. Comparison of these types of trends might be useful.

Comparison of the trends in the abundance between the Scotian Shelf and the Bay of Fundy were investigated prior to 1999, but these trends have not been looked at more recently.

Trends in weight at age might show differences in growth, which is not a stock structure issue but may provide a reason for managing these areas differently.

It was noted that there had been some joint Canada/Soviet Union (USSR) research conducted after 1978 (maybe in the early 1980s by D. Waldron's group). This work had not been reviewed for this data inputs meeting, as it was conducted a long time ago and may no longer be relevant. There was an ichthyoplankton component of the research (did not help with stock structure), with some groundfish work to address more fishery-type questions.

It was asked whether climate change might have an impact on the distribution of the silver hake stock. It was suggested that it might, but this had not been investigated to date and it would be a hard question to answer.

It was noted that information from the Scotian Shelf Ichthyoplankton Program (SSIP) is included in the working paper, but the Fisheries Ecology Program (FEP) data is not yet included in the review. FEP was only done in NAFO Division 4X, but it covers the area where discontinuities in the stock have been proposed. In addition to ichthyoplankton work, the FEP program also conducted seasonal groundfish surveys that may be helpful in looking for discontinuities in distribution.

The Bay of Fundy larval herring survey reported some silver hake larvae, which may be useful to consider.

It was asked whether it would be possible to explore different management configurations during the model review. However, it was explained that it would be difficult to separate the

catch at age. Agreement would need to be reached on the assessment/management area to ensure that the relevant data could be provided for the model review.

There was some discussion on whether silver hake stay within the 4X basins, or whether it was possible that there is migration from the south up into the 4X basins. The Scotian Shelf edge is poorly sampled, and the signal is too noisy to look at it. Length frequencies had been compared for offshore and inshore areas, and there is some evidence for differences in the length-frequencies between these areas; however, this might just be a seasonal difference. The conclusion of past investigation was that the basins might be a nursery area where young fish congregate. The March survey does cover Emerald Basin, and it only catches small fish. A broader age range is observed in the summer RV survey. This would be more interesting in terms of stock structure if there were larger fish in the basin all year.

Figure 20 of the working paper shows ripe and running silver hake, and it does not appear to indicate a discontinuity in the distribution. However, this may be an artifact of having so many years plotted together. Silver hake are serial spawners (2-3 times a year). They can have protracted spawning, but it occurs mostly in the summer.

Recommendations

Document past genetics work, blood work, and rationale for 4VWX management unit in the final Research Document.

Check historical research papers (Canadian/US joint research) to determine if there is any relevant information related to stock structure.

Investigate FEP groundfish results for silver hake; if not, the FEP survey on the Virtual Data Centre (VDC) will be accessed [Note: part of it is there: January to June, 1982-1985].

Include distribution information for silver hake eggs and larvae from the FEP, Bay of Fundy larval herring surveys and SSIP in the final Research Document.

Additional analysis was requested to assist with determination of a stock area for assessment purposes: trends in total or mean catch per tow (strata 440-483, 484-495) and age specific biomass from the RV survey for Bay of Fundy and Scotian Shelf combined and separately; mean catch per tow for the joint DFO/industry Individual Transferable Quota (ITQ) survey combined and separately; catch distribution plots from the RV and ITQ surveys for the full area to help look for discontinuities. Some of this work was presented later in the meeting.

The question of whether Bay of Fundy / Gulf of Maine silver hake might be a transboundary stock should be addressed.

THE FISHERY

Working Paper: Silver Hake Framework Assessment. CSA Working Paper 2012/042.

M. Showell

Presentation Highlights

There have been no foreign catches since 1999, when they were excluded from Canadian waters. All catches have been Canadian and at a lower level since then.

The proportion of catch from Basin and Slope and the distribution of the fishery were presented. The fishery occurs mostly in the basins, with Emerald more popular than LaHave. There is some bycatch of silver hake in the redfish fishery. In 2010, some catches were observed along the Georges Bank line, but only about 50 t. The 2011 catch from the small mesh gear line was noted.

An important change in the fishery included the change in mesh size and shape from 60 mm diamond to 55 mm square mesh when the fishery became "Canadianized". This affected all Canadian licenses right from the beginning. Also, the foreign fishery was conducted from April to August, but the Canadian fishery is year round (dependent on market).

Discussion

A question was asked about the reported catch for 1973 and whether it was likely to be an overestimate. It does not seem biologically possible, and it may have been due to intentional or unintentional misreporting. Similar misreporting has been documented in other fisheries. One explanation is it might have been prorated from a test fishery (i.e., estimation) rather than actual reporting. Earlier assessments only used catch data starting in 1977.

It was noted that foreign catches appear to have reported in 2003. In 2003, there was a joint venture, and catches might have been reported from that (Russian) vessel.

There appears to be a copy/paste error for USSR and total catch for 2009 and 2011.

It was noted that the catch in 2010 appeared too low and may be in error. Egypt was a big market, and when their currency devalued, they stopped buying Canadian silver hake. The main market is now Europe, with some going to the US and Toronto. However, even with that, 2010 looks too low. It should be at least 9,000 t. This was later determined to be an error.

It was noted that the catches in Table 1 and Table 2 in the working paper were not consistent and should be checked.

It was asked whether the distribution of total catches could be plotted (not just the observed catch). There was some discussion about whether plotting of total catches would show any difference in distribution from the observed catches, and whether the observed catch could be considered representative of the fishery. It was suggested that this would be good information to have demonstrated. The coordinates of each set is recorded in the logbooks, and Vessel Monitoring System (VMS) is required. It should be possible to compare distribution from the observed trips to distribution of the fishery from logs or VMS.

If the port sampling and observer sampling is similar, then the observed catches could be considered to be representative of the fishery. However, demonstration of this would be useful.

It was also suggested that the catch along the Georges Bank line should be checked to determine the source of this catch. The silver hake fishery is not allowed to fish that far west, so it might be bycatch in another fishery or an error. It was considered unlikely to be a coding error.

It was asked whether all three sources of information (observer data, port samples, and industry samples) go into the catch at age. It was clarified that they do, but there are no otoliths taken from the industry sampling. It was suggested that if there were a few years where there were samples from all three data sets, these could be compared. It was noted that observer samples come primarily from the 1st and 4th quarter.

A license for squid was issued in 2011, which may have caught silver hake. It did not catch much squid.

Catch indicated just outside of Halifax is probably a key punch error.

It was clarified that, in the last assessment, foreign fishery catch at age was used. Mixing in the location of the foreign fleet was expected, and different gear from the Canadian fishery was used.

Another important change in the fishery that would affect catch composition is that a separator grate was introduced in 1993. There may also be an effect of strengthening straps (and zipper)

on gear selectivity. There was almost no overlap between use of diamond and square mesh in the codend as the transition to square mesh was essentially overnight. There was limited overlap in the distribution of Canadian and foreign fisheries.

Recommendations

Define "basins" and "slope" in Figure 3 of the working paper, or use other terminology.

Check errors in foreign (and total) catch in Table 1 of the working paper. Compare catches in Table 1 and 2 to ensure consistency. Specifically, check 2010 landings as they are not correct. This should be done through MARFIS directly (not the VDC).

Check the catch to the north of Georges Bank.

Plot distribution of the fishery from logbook positions or VMS.

Compare catch composition from observers, port samplers and industry samples for a few years or quarters where all three are available.

Recommend catch at age to start at 1993. Silver hake is a short-lived species, so this might be a sufficient time series. It is worth a try. Pros: would not need to worry about vessel calibration. At a minimum, explore both scenarios – a base case (long time series) and a truncated one. Put the emphasis on the recent period. If there is mixing along the shelf edge, different reference points may be appropriate. However, there is fishing along the edge.

AGEING AND CATCH AT AGE

Current Ageing Method

G. Young and S. Campana

Presentation Highlights

Otoliths are cleared in glycerin, but it is problematic that they continue to clear over time and some structure is lost during long-term storage. It would be nice to have a permanent collection. Currently, only the most recent four years are read. Efforts are being made to try to prevent the age "drifting" seen in other stocks. In the US, a crack and burn approach is used. They imbed and cut individual sections with a microtome, which is labour intensive, but their otoliths are readable for a longer time.

Some ageing is missing but will be completed by July 2012. The full catch at age will be ready by September 2012. Age subsampling uses strata 440-498. Sets from the deep strata 496-498 could be discarded if needed.

Discussion

It was asked if the settling check could be used to determine whether the otoliths might be ready to be read before July. The answer was that there would continue to be some confusion between age 0 and age 1 fish. The age 2 ring could be read now. Problems with reading ages would occur in older fish.

Imaging of the otoliths was tested but was not successful. The whole otolith could not be viewed in one screen shot because of the curve and the number of surfaces. Other tested techniques were also unsuccessful. It was suggested that imaging could be tested again using the new set-up if a box of otoliths was sent to the Ageing Lab.

It was asked if sectioning changed the year count. A match guard comparison was performed but the comparison was not good. Sectioning shows fine scale structure which is hard to interpret. Training would be required to read these sections.

It was recommended that ageing labs in the state of Maine or Massachusetts should be contacted to explore silver hake ageing methods. Sections could be exchanged with Woods Hole to check ages and compare methods. It was also suggested that ages could be checked by having some otoliths read by an ager at DFO who does not usually do silver hake.

After some further investigation overnight, there was an apparent higher mortality rate on older fish. This led to further concern about the ageing of older aged silver hake. It was highly recommended that an independent check of ages be done prior to the analysis of the catch at age.

Recommendations

Silver hake ageing should be attempted using imaging techniques.

Otoliths should be exchanged with other labs, and other ageing methods should be attempted.

Commercial Catch at Age

Working Paper: Silver Hake Framework Assessment. CSA Working Paper 2012/042.

M. Showell

Presentation Highlights

The numbers of silver hake of ages 1 and 2 in commercial landings has increased since 1999. These ages are now a larger component of the catch. This is coincident with the development of the Canadian fishery. Silver hake mature early; 100% of males and 75% of females are mature at age 2. Therefore, the fishery is catching a lot of the fish before they spawn, which is a risky or dangerous strategy.

The commercial mean weight at age is no longer a biological index but could be used for projections. The final year should be checked and compared with Table 4 in the working paper (do not look at the 2011 row).

Discussion

It was clarified that males and females have separate age length keys, and then they are combined.

It was asked if the catch at age takes sex, age, and season into account. It was clarified that the catch at age is broken out by foreign and domestic fishery, quarter and sex. However, there is no strategic reason for breaking it into quarters, and differences among quarters have not been observed.

The 2011 samples did contain a higher proportion of age 0 fish.

It was noted that there could be changes in the fishery based on market. The fishery can target smaller versus larger fish in certain times of the year. The market may demand smaller fish sometimes. Market requirements change weekly, and the fleet reports daily on the size of fish caught.

It was asked if sufficient age samples were taken because some of the sample sizes seemed small for an age-length key. A sample of 200 would be typical. If this sample size is divided by sex, the numbers per sex get low. A coefficient of variation (CV) can be estimated from the catch at age and could be used to optimize this. The CVs by age were compared. The CVs are small for ages 1-3 but increased for some older ages. Ages have to be made up for some of the oldest ages (15-20 fish), but these usually do not represent much of the catch. Industry collects a lot of length-frequencies without otoliths. If someone runs into big fish, they may not get otoliths from the samples. Otoliths from older ages are hard to fill in. The number of fish aged in

each quarter can be increased, but this may not be constructive. The older fish are all aged. Samples that were not aged were mostly where the bulk of the distribution is. It was suggested that selecting otoliths for ageing should not be done by sample. Instead, all otolith samples should be combined and then broken out as 5 per cm per sex bins.

It was suggested that new sampling would be more useful than additional ageing of existing samples. Port samplers at Port Mouton have been asked to increase the number of samples to more than one per month. It is possible to get to Jeddore where boats land fish for packing at 7 am. R. Belliveau will be contacted to discuss sampling.

It was asked if these missing ages could be filled in from the RV survey. It was clarified that the same sampling problem occurs on the survey. They are observed but not always sampled. They are seen in the fishery, so they could be sampled from the fishery. The RV survey ages are not used to generate the catch at age for the commercial fishery.

Some fishing is still occurring along the small mesh gear line. It was asked if the age composition of fish caught had been compared with and without the grate. It was found that 5% of the fish are lost through the grate (do not know if it was Canadian or foreign fleet). This 5% is the larger fish, so there is a different size structure of the catch with a grate. Other fleet changes in gear and fishing practices may also have impacted age composition of the catch. Documentation of this would be useful (proportion of sets for various year classes). For example, tonnage class made a lot of difference for pollock (fish being able to escape the trawls). The foreign silver hake fishery was "offbottom" – within 6 feet.

Older fish have been observed in the RV survey in the past. It is unlikely that silver hake could outswim the survey gear at 3 knots.

Catch at age tracks well from 1999 on for younger fish and then seems to fall off. It is possible that the ages of the older fish are wrong; an independent check on the ages is required. Otoliths should be exchanged with Woods Hole. Ageing methods could be compared at the same time. It might also be useful to do an independent check with someone within DFO who does not usually age silver hake. However, incorrect ageing (should it occur) should only be an issue for older fish.

There was a problem with the catch at age system: the system crashed when an attempt was made to enter age 0s, so had to replace them with 1s. This was not considered to be a major issue.

Recommendations

Describe the methodology used to subsample catch. Also describe the rationale for separating catch into domestic/foreign, sex, and quarter.

Document proportion of sets by various gear classes.

Provide a bubble plot for commercial catch at age and RV survey (on same page).

Show the commercial length at age as well. This will help determine the effects of condition. To disentangle condition, would also need to see length at age. Label the ages on Figure 7 of the working paper.

Explore population models using the full catch at age and catch at age starting in 1993: i.e., a longer base case and a truncated case, although it may be necessary to focus on the recent period.

Additional discussion of sampling is required. Doubling the sampling overall might not be the right strategy. It might be more useful to focus sampling on larger fish (above 35 fish) or smaller fish.

Proposed Ageing Approach

Working Paper: Age Determination Without tears: Statistical Estimation of Silver Hake Age Composition on the Basis of Otolith Weight and Fish Length. CSA Working Paper 2012/041.

S. Campana

Presentation Highlights

A survey of ageing labs was completed a few years ago. It was found that ageing is a big business with millions of otoliths aged every year. A major client is stock assessment. However, it is the catch at age that is required, not the age of the individual fish. When seen from this perspective, there are some new approaches that can be used that are based on very strong biological principles. Fish of the same size will have different otolith size based on growth – ones that reached a size more quickly should have a smaller otolith. More information on growth can be inferred if the size of the fish, the size of the otolith, and the weight of the otolith is known.

The method requires a sample of fish that have been aged and measured, to compare to one that has not been aged. Consistent growth is assumed, and a statistical model is used. Analysis was restricted just to females. Overall, years appear to be similar in terms of growth rate and size, but there are a few differences at older ages (e.g. ages 7 and 8 seem to have a different growth rate).

Assumptions: whatever is used to train the model is broadly representative of the whole sample. Problem is that true ages are not known. This produces imprecision, but this uncertainty already exists within the catch at age. Canno get results from models that are better than this.

Looking at several different models; Omix-S came the closest to the current ageing values (in the order of the ageing uncertainty). This is a best case scenario since it was a subsample. Using a more realistic case, Omix-R came closest. This model did a pretty good job except for age 5; it follows the pattern reasonably closely.

There is currently a single ager for silver hake. Existing samples could be used to age the 2012 otoliths.

If there are samples that are too far from the reference group, the approach would not work as well (e.g. looking at 1990, the approach did not do so well for age 7s; small sample size). This would be a constraint of the approach – do not want to use the same reference collection for too many years in a row. However, it could be used to predict the next year. Do not know how many years to use it in a row. It is also not known if the method could be used to predict commercial catch at age. The commercial fishery and RV survey have different size selectivities.

It would be impossible to use this method on the current silver hake otoliths because they have been in glycerin. Next year, the otoliths could be weighed before they are put into glycerin.

Discussion

It was asked if this method could work for other species. It works well for species in which the age composition is dominated by younger fish, such as silver hake. The method might also work well for herring and salmon. It was asked if this could be done for haddock. It is less effective with long lived species. There would be more savings associated with using it for other stocks.

The method looks promising. It was asked if there is any difference in the two (right and left) otoliths. The two otolith weights are not identical weights, but there is no bias.

It was asked how the method would deal with large year-classes when there might be a compensatory mechanism, such as with haddock. The answer was that it would be very easy to distinguish that year class since they are growing more slowly.

It was asked if the von Bertalanffy growth equation has been calculated from this method. This could be done but the advantage of this method is that calculation of the growth equation is not required. There is a computer program that generates the catch at age directly from this.

The sample size used was about 700. The predicted group was about 200. Given a choice between ageing a small number every year or a large number every three years, the former is preferable. Ageing a small number every year allows verification of growth rates; however, growth does seem to be stable.

It is not common practice in the Maritimes DFO ageing lab to weigh otoliths, but other labs do it routinely.

The change in condition in 1993/94 has been observed in other fish. Length at age has been more stable than condition. There was a decline in length at age early in the time series, but it has been stable since about 1999.

Development of a reference group would prompt the need to check for any ageing errors.

Potential for ageing errors could be incorporated into the modeling (as a source of uncertainty).

Recommendations

Attempt to generate the indices for a few years to review at the silver hake assessment meeting.

This working paper was accepted for conversion to a Research Document.

SURVEYS AND OTHER INDICES

Working Paper: Silver Hake Framework Assessment. CSA Working Paper 2012/042.

M. Showell

Research Vessel Survey

Presentation Highlights

A stratified random design groundfish RV survey has been conducted on the Scotian Shelf from 1970 using three Canadian research vessels (*A.T. Cameron, Lady Hammond* and the CCGS *Alfred Needler*). The Bay of Fundy and approaches are excluded in the indices. The survey is not stratified specifically for silver hake, but the stratification that is used is not worse than if there was no stratification.

Based on an analysis of comparative fishing experiments by Fanning (1985a), a conversion factor of 2.3 is applied to the abundance series prior to 1982 to account for the effect of vessel and gear changes between the *A.T. Cameron* (lower trawl) and the other two vessels. The same conversion factor was used to adjust biomass estimates. This conversion was based on a limited number of observations. There is still a retrospective whether the conversion is used or not. No conversion factor is required between the *Lady Hammond* and the CCGS *Alfred Needler* for this period. The survey was conducted by the CCGS *Teleost* in 2004 and 2007. An analysis of comparative fishing experiments showed no conversion factor was required between the two vessels for silver hake. The conversion factor is not an issue if abundance indices from the more recent time period are used.

Distribution at RV Survey Catches: There is no apparent break in the distribution of silver hake when observing the recent distribution of RV survey catches (2008-2011). This may be

evidence for reconsidering excluding the Bay of Fundy strata from the abundance indices generated from the summer RV series.

Total Biomass: 1970 to 2011.

Total Abundance: 1970 to 2011.

Recruitment: 1970 to 2011. Would normally shift over by one year and call it year-class. See 2009 year class as the largest in the recent time series.

2+ biomass: seeing an increase.

There have been some concerns about how the summer RV abundance indices are affected by biological changes. Declining condition could affect catchability as more fish can escape through the meshes of the RV survey net. A change in prey species composition could cause changes in catchability. More silver hake could be up in the water column; this could be checked using the stomach database. Silver hake could be moving into deeper water; however, there are no fish appearing in the deeper (496-498) RV survey strata.

Discussion

Differences in fish size between the research vessels were examined during the conversion analyses. The results are available on the NAFO website (Fanning 1985b).

The 2009 year-class appears to be the lowest in recent years in the commercial catch at age despite being highest in the RV survey.

Length frequency data for the most recent summer RV survey is not in the working paper. It is available in the 2012 RV survey trends report (DFO 2012).

It was suggested that, since silver hake are sexed, a spawning stock biomass (SSB) estimate could be generated by assuming 75% of females are mature at age 2. There is no SSB index; all females are assumed to be mature at age 2.

There was some discussion about how best to provide estimates of total mortality (Z) based on survey catches. Figure 20A in the 2010 silver hake research document (Showell et al. 2010) and Figure 9 in the 2010 Silver Hake Science Advisory Report (DFO 2010) were suggested as good examples to be followed. A figure showing survey Z was requested for the next day.

Recommendations

Add table for 2+ biomass.

Plot female-only spawning stock biomass (such as age 2+ or something fancier).

Plot total Z for ages 1-4 as in DFO (2010).

Summarize length frequencies from the survey (e.g., DFO 2012).

Update proportion of females (sex ratio).

Update maturity ogive (percent mature females at age) to determine whether age at maturity of females has changed over time.

Industry Survey

Presentation Highlights

The ITQ survey does not cover the whole area occupied by the silver hake stock. However, it does cover the inshore area better than the summer RV survey. There are not a lot of silver hake there. Catches from the most recent survey have not been plotted yet.

Discussion

It was asked if all of the ITQ stations are sampled every year. The survey covers the whole area of discontinuity between Scotian Shelf and Bay of Fundy. Some stations have been added on. The largest number of additions was in 1996. The first year, 1995, is not included in the series. There is no core set of stations and some differences in stations sampled from year to year. When abundance indices for NAFO Division 4X cod were generated from the ITQ survey, only stations sampled every year were used. Some stations have been dropped stations due to gear conflicts and these are excluded. Stations have not been dropped if they were not done for a single year. This is a simple mean anyway.

Smaller fish are caught in both the ITQ and the RV survey in the slightly deeper water.

Recommendations

Plot the distribution from the ITQ survey as supporting evidence for the management unit.

Plot trends in total strata and for the Scotian Shelf and Bay of Fundy separately.

Other Indices

Presentation Highlights

The Russians conducted surveys of 0 group silver hake on the Scotian Shelf in October from 1980-1997. The survey indices were used as a tuning index in the VPA for a number of years. A similar survey was attempted for 2 years using the Needler (DFO research vessel), but it was unsuccessful.

There are lots of silver hake in the diet database. These could be looked at for abundance indices.

DFO's 4VsW Spring Survey is not informative.

Discussion

It was suggested that DFO RV survey trends could be compared to the US fall or spring surveys to see if there is a stock-recruitment relationship. Maybe just the Georges Bank survey.

The Georges Bank RV survey trend will be presented on the second day. Silver hake appear mostly on the southern flank in warmer water.

Commercial Catch Rates

Presentation Highlights

The catch rate from the foreign fleet is a candidate for an abundance index. The fishery is conducted in a limited geographic area using similar vessels, gear, methods and primitive methods for finding fish. Catch rates were used as a tuning index in the VPA in the past. These were standardized by NAFO area, country and month. The series ended in 1999 when the Russians were excluded from the Canadian zone.

CPUE is not just influenced by the vessel but also by the skipper.

Relative fishing mortality (F) was plotted as the ratio of commercial catch over the stratified total biomass estimate from the RV survey.

Discussion

Conditions required for a standardized catch rate were discussed. Catch rates are affected by the market, which has been mainly a fresh fish market since 1995. Tows are shorter and more care is taken by the crew. The skipper's name is not recorded in the log, but for the last 6 years,

there has been no turn-over in skippers for 70% of landings. Skippers tend to stay with a vessel. A vessel effect (CFV) should be examined using a set of six vessels since 2000.

There should be two seasons since some changes occur in the fishery through the year. Fishing is consistent from December to February. From March to May, they canno control fishing as fish leave the basins and boxes, while fishing is limited to certain areas.

There may also be a diurnal effect with fish abundance different for morning and mid-day. These should average out. Eastern winds are coincident with decrease in fish.

Estimating fishing effort as tons per day or tons per hour was discussed. Previous catch rates used actual days. The recommendation was for set time as actual hours (duration) in the water.

This type of index would probably be useful.

Recommendations

Develop a mixed effects model using a core group of vessels that have kept the same skipper since 2000, with CFV as a main effect. Vessels with a different trend could be excluded. Catches should be divided into two seasons: Dec – Feb and March – May. Also, effort should be based on actual hours (duration) in the water instead of days.

If the catch rate is used as a tuning index, the mean square residual could be looked at to see if it improves the model fit.

BIOLOGICAL AND ECOSYSTEM INFORMATION

Biological Information

M. Showell

Presentation Highlights

Condition and mean length-at-age has declined. This means low mean weights at age. Condition was shown by plotting weight at 25 cm (calculated for males and females and then combined).

The proportion of females over time from the RV survey (females disappearing) is changing. It would be important to update this and consider the impacts on fecundity.

Spatial distribution from the RV survey from the VDC was presented - 60% were non-zero and 40% were zero.

Discussion

Other sources of recent information on biological characteristics were discussed. The last assessments in the US were done in 2006 and 2011. These did come up with a new assessment analytical model. There was no new information.

Males and females should be kept separate to estimate condition. Use age 3 for females (100% mature) and continue to use 25 cm for males.

Typically, a different metric for area of occupancy is used (e.g. DWAL). Changes in area of occupancy for spawning biomass (in addition to total or juvenile biomass) should also be examined.

Area occupied metrics are available on the VDC. Stratum weighted area occupied is the most recent.

Recommendations

Check last US assessment for any new information (2006 or 2010).

Separate males and females in condition index. Use size at age 3 for female index. Use size (25 cm) at age 2 for males.

Document reduction in the proportion of females in the RV survey.

Investigate area of occupancy for spawning stock biomass and immature silver hake separately from VDC.

Fishery Footprint (Part 1)

J. Black

Presentation Highlights

Figure 1 is a demonstration of spatial analysis work done in 2008 to identify Ecologically and Biologically Significant Areas for the Maritimes Region. It uses a method that partitions landings in the bottom third, middle third, and top third, to show where most of the landings are occurring, as well as partitioning effort into days fished. It demonstrates that most effort is less than 2 weeks. It was noted that there might be some bad data (wrong coordinates) from the Maritimes Fishery Information System (MARFIS). The distribution of fishing effort in 2007-2011 appears to be fairly similar to that in 2011 alone (Figure 2).

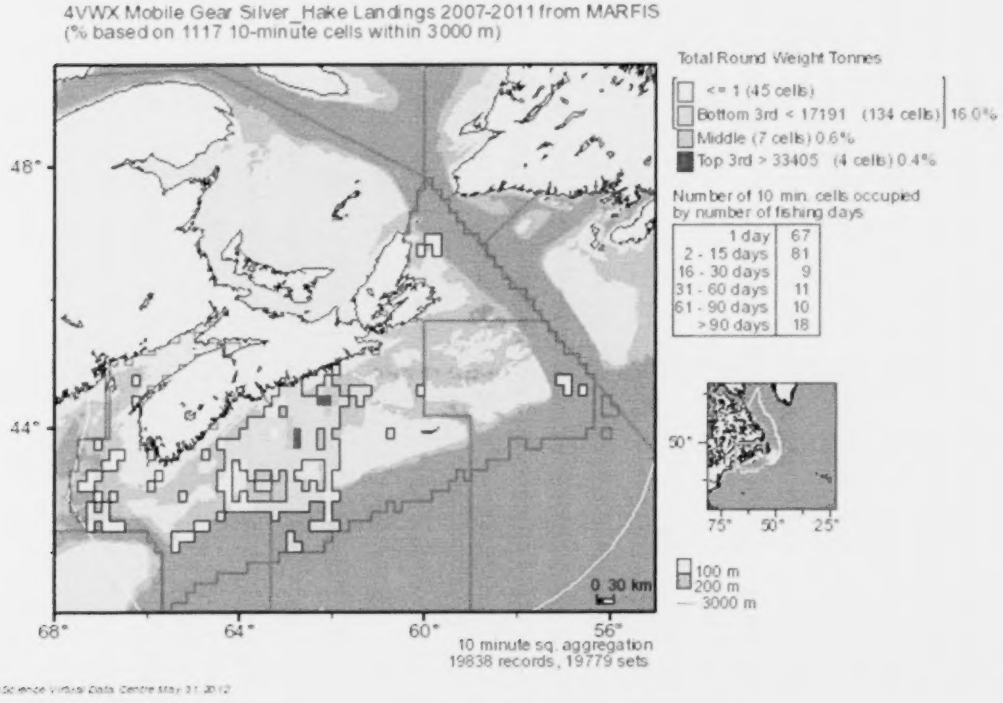

Figure 1. Distribution of silver hake landings from MARFIS in 2007-2011.

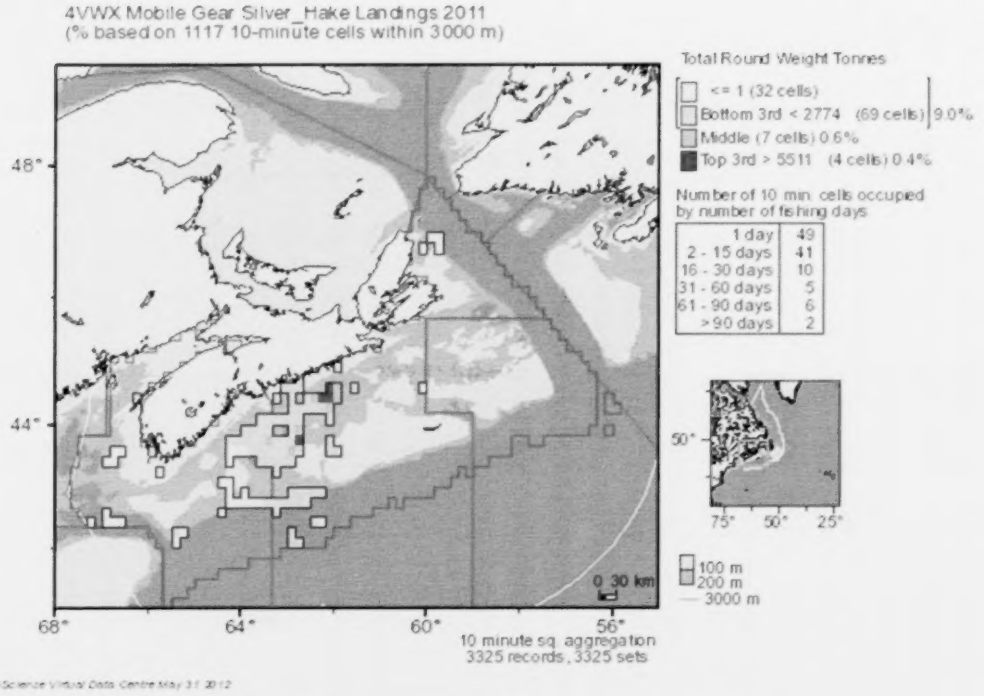

Figure 2. Distribution of silver hake landings in 2011.

Discussion

It was clarified that the greater than 90 days was cumulative over the time period (not annual). The weight is probably prorated based on landings. All mobile gear may have been included in the analyses since the catches were not sorted by mesh size

The relevance of this analysis was questioned. A lot of other work is required for this framework. It was suggested that, in addition to supporting work on potential habitat impacts, it does present another way of looking at the fishery distribution information. Bubble plots do not really give a good indication of the distribution of the fishery.

Spatial assessment models do exist, though none have been considered for 4VWX silver hake. It is still important to consider the spatial aspects of the population and fishery. This is one way of stimulating discussion.

This type of information may be useful for eco-certification purposes. Landings data have not been sufficient for Marine Stewardship Council certification of scallop, but this has not been asked for in groundfish. It would be in industry's best interest to get a more precise estimate of their fishery footprint.

Recommendations

In addition to the plot provided by J. Black, include a plot that limits analysis by mesh size (55-90) with that gear to distinguish targeted and non-targeted [see additional information provided below]. This could also be divided into the two proposed seasons to get the temporal distribution.

A subset of landings could be linked to the VMS data and crossed against logs as an independent measure of effort. Speeds can be obtained from VMS data (use derived speed).

Based on distribution of speeds, one can estimate when fishing occurs. If landings are reliable, a separate CPUE can be calculated from VMS in addition to logs. VMS prorated to landings. This can be used to validate log records.

Analyses of the 2002-2009 silver hake fishery are available from Oceans and Coastal Management Division, DFO. The scale should be checked as this does influence the results. VMS would help to fine tune the analyses.

This analysis requires a more refined question.

Fishery Footprint (Part 2)

A new figure from J. Black was reviewed, which only included mesh sizes from 55-89 mm (Figure 3). This did not appear to change the distribution of the fishery much. It just removed some of the silver hake taken as bycatch in other fisheries. The top 10 cells are the same from year to year. There are still records north of Georges Bank.

Another figure was provided for 2011 alone (Figure 4). This indicates a smaller footprint (as expected).

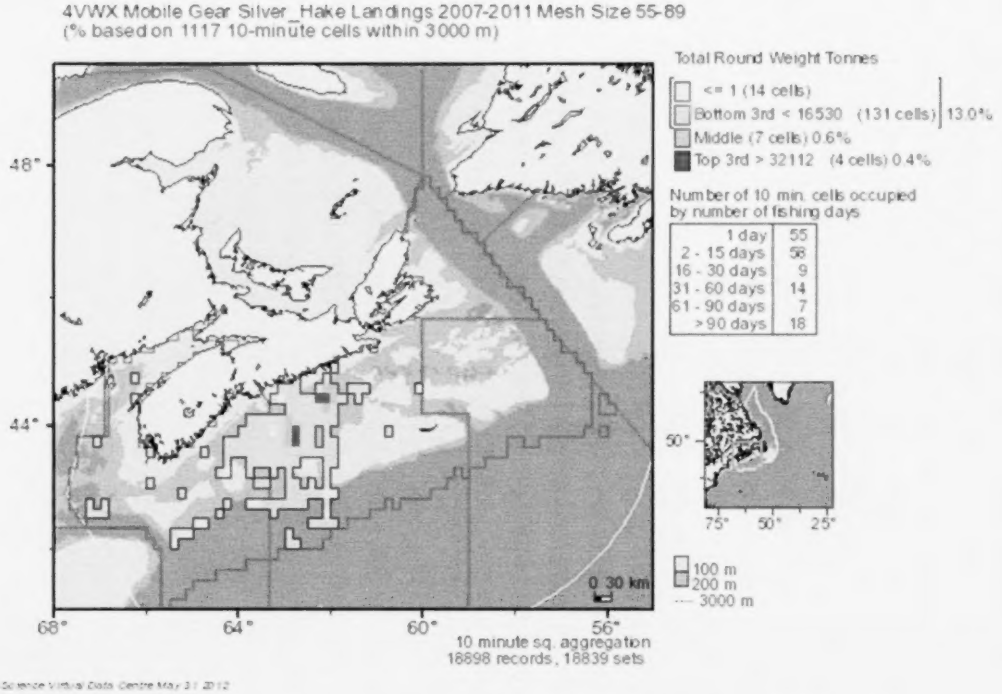

Figure 3. Distribution of silver hake landings using mesh size of 55-89 mm (2007-2011).

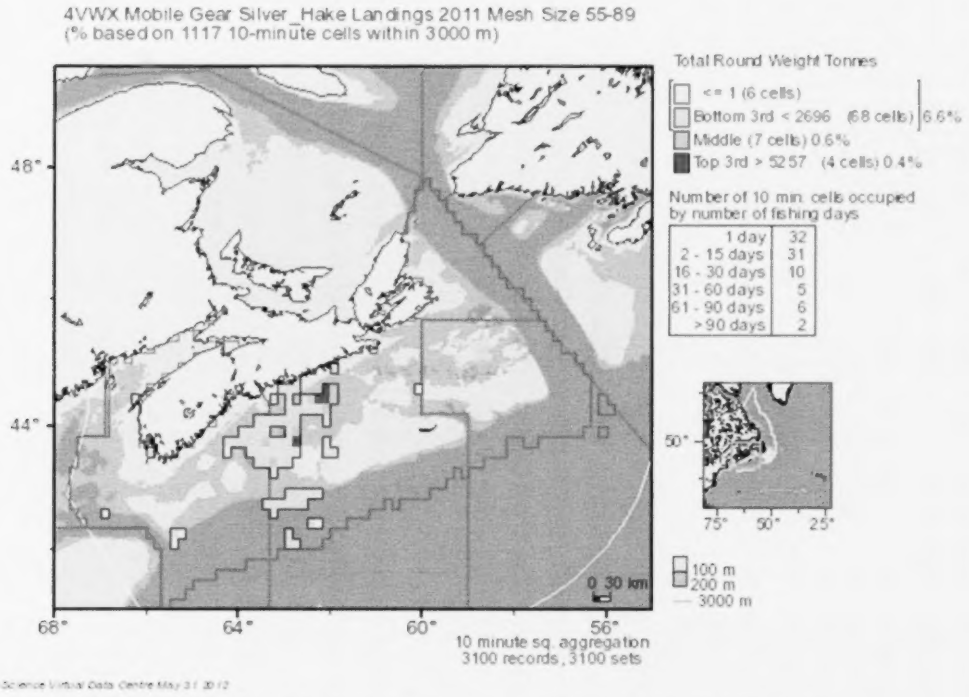

Figure 4. Distribution of silver hake landings using mesh size of 55-89 mm (2011).

Discussion

It was asked how deep the fishery can fish. It was clarified that silver hake fishing typically occurs at 700 fathoms or less.

J. Black should be consulted to ensure the analysis was limited to groundfish mobile gear only and did not include shrimp gear.

Some concern was expressed that, if the Sensitive Benthic Area Policy goes through and there are two additional closed areas for *Vezella* sponges, this would impact the silver hake fishery.

Bycatch

M. Showell

Presentation Highlights

Kept and discarded catch from the silver hake fishery for the last 10 years (2002-2011) were provided based on observer database records. Herring was the largest non-silver hake bycatch at 1%. Other species were less than 1% of the catch. The silver hake fishery catches lots of species but not many of any one kind.

Discussion

Any species of concern, e.g. evaluated as endangered, threatened or special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or the *Species at Risk Act* (SARA), such as some skate species, basking shark, and Atlantic cod, should be included in the table. The terms 'offshore hake' and 'squid (NS)' were discussed. It was clarified that the percentage of catch was calculated from total catch. The question of, 'what is an adequate level of observer coverage?' was discussed but can be difficult to determine. The estimate of

discarded silver hake was questioned since silver hake cannot be discarded. It was clarified that these were damaged fish or resulted from net tears.

The records of kept lobster should be checked as to whether they were really discarded lobster or keypunch errors.

SARA logbooks are available but the silver hake trips may be difficult to identify. It would be possible to sort by mobile gear <65 feet.

Recommendations

Include all species in the bycatch species table in the Research Document. Include the level of observer coverage as percentage of observed landings.

Check any SARA logbook records if possible to distinguish silver hake trips.

COMPARISON OF CANADIAN AND US SURVEY TRENDS

A. D'Entremont

Presentation Highlights

A comparison of the US survey trends with Canadian survey trends, based on information acquired from US assessment reports and Canadian data. Areas discussed are displayed in Figure 5.

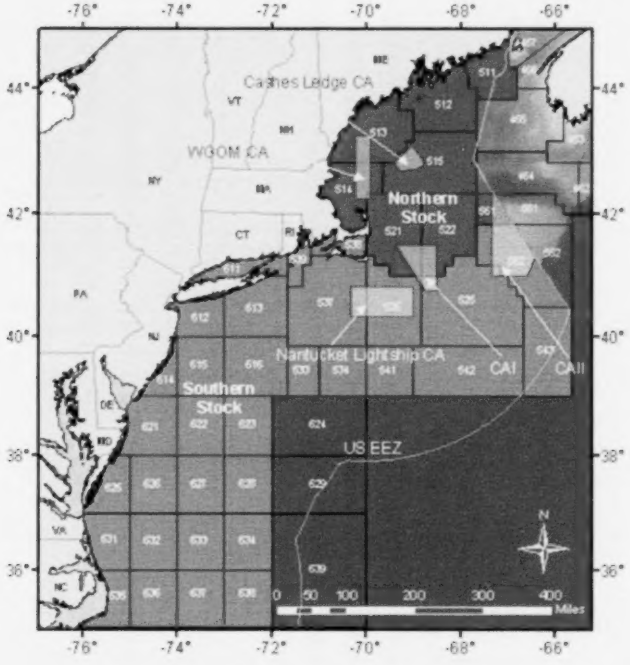

Figure 5. US survey strata and stock areas.

The recruitment index and 3+ biomass for Northern and Southern US fall surveys are shown in Figure 6.

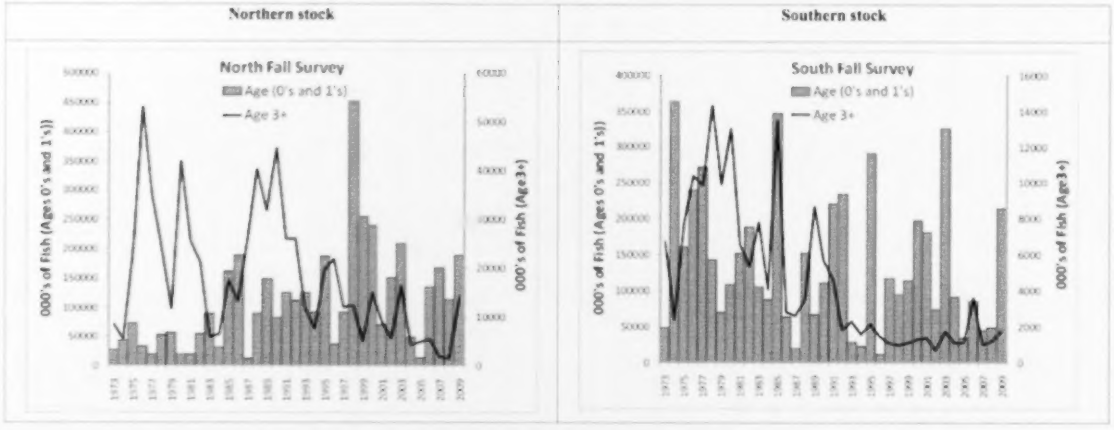

Figure 6. Trends in fall survey abundance by age group for silver hake in the Northern and Southern US stocks (NEFSC 2010).

A comparison of the Canadian RV survey catch per tow and the trend for the US Southern stock, show that they are somewhat comparable in terms of overall trends. The US Northern Stock did not seem as comparable (Figure 7).

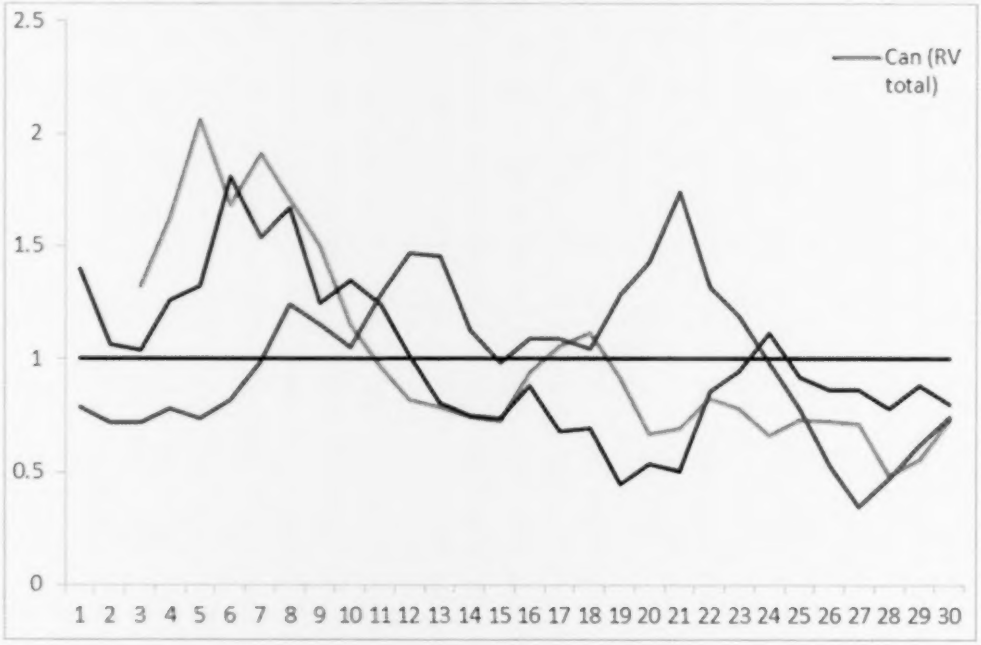

Figure 7. Comparison of the Canadian RV survey trend with the US Northern and Southern stocks.

Looking at the Canadian survey trends alone, there appears to be limited influence of Bay of Fundy on the combined index (Figure 8). This is not surprising given the Bay of Fundy has about half the catch rate of the Scotian Shelf and represents a smaller area.

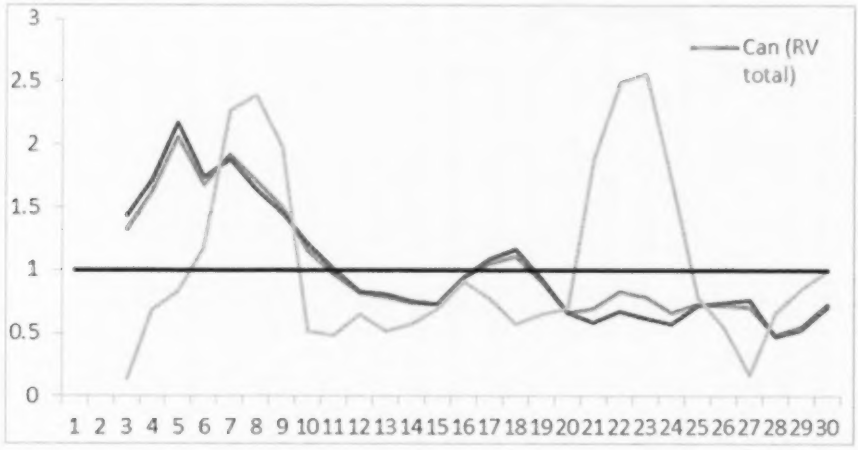

Figure 8. Comparison of the Canadian RV survey trend for the Scotian Shelf (SS), Bay of Fundy (BOF) and combined.

Discussion

There was some discussion on whether efforts should be made to acquire the raw US data to attempt to fit a model. It was agreed that it would be a lot of work to rebuild the catch at age, though it may be possible to just use the two that exist and add them together. However, they do not cover the same area.

Recommendations

Recommend using a simple correlation table to provide more objective way of comparing the survey trends.

After some further review and discussion, it was agreed that the information available does not support adding the Bay of Fundy to the catch at age, and it was agreed that the assessment should continue to be based on the Scotian Shelf component only.

MODEL CONSIDERATIONS

- Base Case – traditional VPA formulation:
  - Age-based VPA
  - Was used for a few years – people might not have looked at it closely enough
  - Always had a retrospective
  - Tried a number of different tweaks: Truncated data, etc.
  - Hoping for something different
- Possible alternative models for exploration: stage-based model or delay-difference model.
- Need to resolve if there are ageing errors.
- S. Martell will be coming to do a week long workshop on modeling in September: will be looking at statistical catch at age models – from simple surplus production models to more complicated models. This will provide a week to talk about what works and what does not.
- Selection of a model will depend, in part, on how much confidence there is in the data.

- Sharp contraction of age structure in catch in 1993 may cause problems for the model, but it would be possible to set objective function to account for this and make use of different time periods.
- This change in 1993 should not have an influence on the retrospective now, but it may be a reason to truncate the data. Still had a huge retrospective in 2009.

MANAGEMENT CONSIDERATIONS

- It would be useful to have a model with the ability to generate/support reference points and harvest control rules.
- Given a potential 5 year assessment cycle, the ability to provide projections would also be important.
- Without this ability, a more empirical approach to the development of harvest control rules may be required in the interim. RV survey trends will be reported and monitored.

SUMMARY OF RECOMMENDATIONS AND NEXT STEPS

Management Unit / Stock Structure

Review of information presented at this data inputs meeting suggests that using Scotian Shelf RV survey information (excluding the Bay of Fundy strata) as an index of abundance will be adequate to reflect the relevant silver hake population.

Next Steps

- Document past work, including:
  - Genetics work
  - US blood work
  - DFO Maritimes rationale
- Document silver hake distribution between Scotian Shelf and Bay of Fundy (as evidence to support management unit):
  - RV survey (longer time series)
  - ITQ distribution
  - FEP groundfish surveys
- Document survey trends for Bay of Fundy / Scotian Shelf separate and together.
  - mean catch per tow in RV and ITQ surveys
- Document egg/ larvae distribution information:
  - FEP ichthyoplankton survey
  - Herring larval survey
  - Historical 0 group survey

Fishery Information

Check

- Errors in foreign (and total) catch in Table 1.
- Match Tables 1 and 2. e.g., 2010 landings do not seem to be correct.
- Catch to the north of GB.

Plot

- Distribution of landings from the logs or VMS.

Analysis

- Compare catch composition from observers, port samplers and industry samples for a few years/quarters where there are all three.

Ageing

Short-term

- Currently subsampling using strata 440-498 – discard deeper sets?
- Describe subsampling procedure.
- Complete ageing (before July, if possible).
- Attempt to generate catch at age from otolith weights for assessment – Steve
- Provide commercial length at age

Longer-term

- G. Young to provide samples for re-imaging attempt.
- Exchange with Woods Hole to do independent check of ages and compare methods (sectioning) (attempt to bring samples to TRAC meeting in June)
- Local independent check on ages also.
- Explore ageing methods used in Maine.
- Try method for haddock.

Commercial Catch at Age

- Describe rationale for separating into foreign/domestic, quarter, and sex. Note differences by quarter.
- Document proportion of sets by various gear classes?
- Label ages on Figure 7.
- Provide commercial length at age (to help disentangle condition).
- Provide bubble plots for commercial catch and RV survey on same page.
- Explore using full catch at age and catch at age starting in 1993, i.e., base case and a truncated case, though might want to put the emphasis on the recent period.
- Additional sampling – focused on larger and smaller fish. Have already talked to port sampler in Jeddore.

RV Survey

- Table for 2+ biomass.
- Female-only spawning biomass plot (age 2+ or something else).
- Survey Z for ages 1-4 as in DFO (2010).
- Summarize length frequencies.
- Update sex ratio (proportion females).
- Maturity ogive (percent mature) – have they changed maturity over time (just females)?

ITQ Survey

- Plot ITQ survey catches.

Other Indices

- Investigation of diet database – predators/prey description.
  - Enough information to do a time series? 1970s, 1980s, 2000s.
  - Do not see the cannibalism to the same levels as reported elsewhere.
  - Eaten more frequently by cod and haddock (under 200 records of young of the year being eaten).
  - Seals? Do not have that data – might have to check with D. Bowen.
  - Herring, shrimp, krill top prey in more recent years.
  - 35-40% are still intact when come on board (stomachs everted).
- 0 group survey documented.
- Explain that 4VsW survey not informative.
- US fall/spring survey for context.
- Georges Bank RV survey results.

CPUE

- Recommend looking at (6) core vessels to develop a CPUE index (provided by industry).
- Based on hours (duration) in the water.
- Start in 2000. Use two main seasons: Dec – Feb, March – May.
- Mixed effects model with CFV as a main effect.
- Check mean square residual to see if using this as a tuning index improves model fit.

Biological Information

- Check last US assessment for any new information.
- Separate males and females in condition index. Use size at age 3 for female index. Use size (25 cm) at age 2 for males.
- Document reduction in proportion of females in the RV survey.
- Use area of occupancy metric available through the VDC.

Fishery Footprint

- Use J. Black's method but focus on silver hake fishery, divide into two proposed seasons.
  - Did restrict to mesh size.
- Use VMS and cross check against landings.
  - New VMS boxes require reporting speed.
- Check with S. Coffen-Smout (revised human use atlas).
- Clarify question that this information attempts to address.

Bycatch

- Include full species list, and any SARA species or commercial species at a minimum.
  - Less than 0.1% seems more reasonable.
- Define "adequate" level of coverage.
- Check lobster "kept versus discarded."
- Check any SARA logbook records, if possible, to distinguish silver hake trips.

PART 2: MODELLING REVIEW (NOVEMBER 15-16, 2012)

INTRODUCTION

The chair of the meeting, T. Worcester, Coordinator for the Centre for Science Advice in the Maritimes Region, welcomed everyone and thanked them for coming to this DFO Science Peer Review of the Assessment Framework for 4VWX Silver Hake.

As described in the Terms of Reference (Appendix 1), this second meeting of the framework review was to review the assessment approach, including data sources and assumptions, to be used in the 2012 assessment.

Participants (Appendix 2b) were encouraged to ask questions of clarifications and to participate actively in the discussion. It was explained that the meetings would operate by consensus, where possible.

The Agenda (Appendix 3b) was reviewed, and nothing further was added.

REVIEW OF THE MANAGEMENT UNIT

Working Paper: Silver Hake Framework Assessment Part 1: Data Inputs. CSA Working Paper 2012/62.

H. Stone

Presentation Highlights

The management unit was reviewed as well as the rationale for excluding the Bay of Fundy survey data from the biomass index. The summer RV survey has the best coverage and is the primary index. Survey trends in the Bay of Fundy are much more variable and represent less than 10% of the total survey biomass.

Growth is similar in the two areas.

Trends in the NMFS fall survey series in the Gulf of Maine North show similarity with the Bay of Fundy, while the other NMFS series show greater similarities with the Scotian Shelf.

Exploitation is primarily on the Scotian Shelf. Some catches in the western portion of 4X and Bay of Fundy in the 2000s may be linked to the US Gulf of Maine.

Egg distribution is available from the SSIP and Larval Herring Survey database (Sep/Oct, 75-95). Evidence of spawning occurs throughout the distribution, so it is not clear from these data whether there are different stocks.

Recommend using strata 440-483 for survey indices since these provide a better match with the distribution of the fishery.

Discussion

Southwest Nova Scotia is not really a large spawning area, but it has many years of data. Abundances are quite low in comparison to SSIP data. Peak spawning is in the fall.

A previous comparison of abundance of ages 1 and 2 from the summer RV survey and US fall survey data showed a relationship between the Gulf of Maine and Bay of Fundy, but not between the Bay of Fundy and Scotian Shelf.

Big year classes generally show up in both areas, but not always.

It was asked if the timing of maturity between Bay of Fundy and Scotian Shelf had been investigated. Few fish ages 3 and 4 are available from the Bay of Fundy to investigate this.

REVIEW OF DATA SOURCES AND ASSUMPTIONS

Working Paper: Silver Hake Framework Assessment Part 1: Data Inputs. CSA Working Paper 2012/62.

H. Stone

Presentation Highlights

There is some indication of increasing age structure in the population since 2008. The full catch at age goes back to 1977, but there were changes in the fishery (Nordmore grate, etc.) that support splitting the catch at age at 1993. The Canadian fishery was well established by 1998.

Landings by the foreign fleets were >100,000 t in the 1970s, >50,000 t in the 1980s and early 1990s, then drop to less than 10,000 t in the 2000s. It is unclear whether they are sustainable at these levels.

Total mortality (Z) and relative F on age 1 have increased since mid-1990s. Relative F declined for ages 2-3 in the early 1990s (end of the foreign fishery) but Z remains high with no decline. Similar trend are seen for ages 4-5, where relative F declined in the early 1990s but Z remains high with no decline. Relative F at age has changed over time, with more removals of ages 1 and 2 in the recent period and with fewer removals of older ages.

A standardized catch rate series for 1998-2011 was developed using a main effects GLM to standardize for effects of year, period, area and vessel. Landings and effort data were restricted to the basins. This series shows a significant year effect, with an increasing trend until 2008 and then a declining trend.

Weight at age shows a declining trend for ages 2-6 to 1994, then levels off for ages 2-4 or increase again for ages 5-6. The weight at age is generally level for age 1. These are used in the VPA and Integrated Statistical Catch Age Model (ISCAM) models. The survey weights at age are generally higher than the fishery, except for age 1.

The calculated condition factor (Fulton's K) shows a declining trend. It has been at or below the long-term average since the early 1990s. This factor is probably environmentally driven.

There are proportionally more older fish in shelf slope strata in spring compared to basin strata; however, the basins may be considerably higher.

Depths sampled by the survey were compared to the fishery to see if the survey covered the depth range of the commercial fishery. The survey samples down to 400 m, but most tows within depths <=200 m. Observed sets occurred mostly at 100-300 m, with some at depths >300 m. The conclusion is that the survey generally covers the range of the fishery.

The 2012 spring RV survey shows a strong peak of abundance at 12 cm and a second peak at lengths 26-27 cm, representing age 1 and ages 2-3, respectively. The summer RV survey shows a modal progression in the size of age 1 with the first peak at 17-18 cm and the same second peak at 26-27 cm as shown in the spring survey. The 2009 year class appears to be strong at age 3.

Ageing appears acceptable for the assessment. There was no definitive evidence that the ageing was great, but nothing that was pathological. Comparison between agers showed some differences, but both were tracking year classes. There was some difficulty in determining the first annulus while the second one was clearer.

Discussion

There was some discussion about why the survey is consistently bimodal and the fishery is not. The survey is conducted in July, while the fishery occurs throughout the year. The smaller fish caught in the survey have not grown enough to be caught by the fishery early in the year. A similar pattern is observed on the US side. There is a period in fall (September) where it is more hit or miss; the fish do not appear to be in the basins at that time.

It was suggested that the change in relative F might also be a truncation of the age structure, in addition to the selectivity.

It was asked if there was a seasonal change in the weight at age in males and females. This is likely but cannot be verified since sampling only occurs in the summer.

The summer RV survey appears to provide useful data for assessing silver hake. It would be useful to come up with some mechanisms to explain the observed increase in natural mortality. Changes in predation have been considered in the past. It was asked if there was any evidence that predation has increased.

The Maritimes Region does have a decent stomach database including some mid-1980s and pre-1970s data. Little predation has been observed on silver hake, but this may be confounded by the season of sampling. Work by D. Waldron in the 1980s showed more seasonal changes in consumption.

What about non-fish predators? There is some information on seal predation on silver hake. When up on the shelf edge, seals would eat silver hake but they would not necessarily search them out in the basins. When silver hake are on the banks, their gonads are healthy. In the late 1980s, in summer sampling on Sable Island, silver hake otoliths were found in seal stomachs.

Natural mortality seems to be higher on males rather than females. This may be related to spawning maturity rather than consumption by predators. The relatively higher M may also be related to sexual dimorphism in silver hake. Also, size relative to mortality could be investigated. There is some information on life history that might be useful. Size is similar to that observed for US stocks. The relationship between size and M has been explored in the US for yellowtail flounder but not yet for silver hake.

The shift in M is coincident with the appearance of smaller fish. Could this be related to escape or incidental mortality? Is there any idea what the magnitude of this effect might be (fish going through the grate)? Higher M is on the older fish, though. Being squeezed through a small mesh might be more of a problem in terms of mortality than the grate. Foreign fleets were not required to use the square mesh – still using the diamond mesh.

With the fishery moving to the basins, not a lot of time is spent looking for younger fish. The fishery is not actively targeting the smaller fish. LeHave Basin has smaller fish, so vessels might move to there to get smaller fish. The three companies have different markets: one focussed on smaller fish, the other two make use of the big fish, selling larger fish to the US or Spain.

It was asked what ages the grate is intended to exclude. The silver hake fishing gear is meant to catch fish ages 3 and 4; age 5s should be excluded from the grate. The grate was implemented in the foreign fleet in August 1993, so the biggest change in catch composition would be expected in 1994. They were designed to exclude cod and haddock. Halliday and Cooper (1997) did a special study on the grate.

Even though the fishery uses the grate, a truncation of the size structure has also occurred in the RV survey catches.

Landings are not controlled by the total allowable catch (TAC). Annual catches have been well below it. There is a worldwide market for silver hake, e.g. market in Egypt. The highest landings have been 11-12,000 t. With the economic collapse, the silver hake industry is only selling 9,000 t. Catch rates are a better indicator of abundance and more consistent with the biomass trend.

It was asked how well the standardized catch rate series appears to fit expectations. More noise is apparent early on in the series. As vessels gain experience, the noise is reduced. Catch rate series is not reflecting the population as it is restricted in area. A target F is not set for the fishing area but for the whole population. Area interactions were not found to be significant. Emerald Basin is similar; LeHave Basin provides slightly less catch rates. The reason it works is because the captains and vessels have remained the same over time. Catch rates are not increasing as much as the summer RV survey index. Need a one year lag (move it behind). Use it as a source of information but not within the model.

REVIEW OF POSSIBLE ASSESSMENT MODELING APPROACHES

Integrated Statistical Catch Age (ISCAM) Model

Working Paper: Modelling 4VWX Silver Hake with a Statistical Catch at Age Model (ISCAM). CSA Working Paper 2012/63.

D. Themelis

Presentation Highlights

The data inputs to the catch at age model are described in the paper. The survey indices are contradictory with RV survey going up and ITQ survey going down recently.

A number of model runs were attempted:

- Base model: fixed M of 0.4,
- Random walk M
- Time varying selectivities
- Short time series (1993-2011)
- Split series (at 1993)

When all data from 1970-2011 were used, a very high RV survey q (10.8) was generated. R. Halliday suggested that the data before 1977 is not believable.

Base Model had a fixed M of 0.4, with landings, RV survey and catch at age starting in 1977, age at 50% selectivity from 1 to 1.5, and priors on q. In this mode, the initial biomass was 407 t.

The base model showed very little flexibility with fixed M and selectivity and frequently failed to converge.

None of the model runs were very satisfactory, but the Base model was the most honest. There are a lot of switches in the ISCAM program that were not fully understand. It would be useful to have recommendations on which to pursue.

Discussion

It was clarified that the coefficient of variation on survey catchability was 0.4. If too tight, CVs might need to be increased to improve flexibility in the model.

It would be interesting to see the catch composition in the domestic and foreign fleet in the Smart model (allow selectivity to change in the RV survey).

The last model might indicate a danger of overfitting. The penalty tries to stop that, but it's an ad hoc approach.

Be careful of manipulating the survey catchability without providing a rationale for doing so, otherwise the results will not be meaningful.

A natural mortality of 1 does not seem high. The model kills fish off because of the large landings in the early period. However, when the series is split at 1993, the model still generates an increasing M and the scale of the change is still very high. Z is high.

There needs to be some guidance on what q should be. Some numbers are impossible. If q is considered as a scalar between the survey and the model, then it can be anything. If q is considered to strictly represent the catchability of the survey, then a value above 1 is unlikely as it is hard to catch a fish in a survey (do not expect to catch everything, which would generate a q of 1). There is no reason that q should increase with age. If q is wrong in the model, management measures that change the ratio of F to M are unlikely to have the expected effect.

Silver hake tend to exhibit a diurnal effect.

The fishery uses certain gear in order to catch silver hake, and the RV gear does not do anything to improve catchability (e.g. gear lift, herding).

Is there a reason to believe that the location of silver hake has changed? Silver hake are influenced by temperature, and temperature has changed. The availability of suitable habitat may have changed.

No fishing is occurring on the Gulf of Maine stock and there are still no large fish. This could be related to habitat preference.

When there was fishing in NAFO Division 4X, large silver hake were observed up to 50 cm in the Crowell Basin. This might just be a seasonal pattern.

The Smart model is not recommended, as it was felt to be better to dump noise into M rather than into the selectivity.

In the Basic model, the retrospective problem (the fact that it underestimates every year) would need to be addressed.

In the short series, the B_{MSY} = MSY is concerning. A q of 1.8 is also concerning.

How well is Beverton-Holt being fit? If this relationship is not strong, then one might not want to calculate B_{MSY} internally -- might want to do it externally.

Attempting a 9+ model without a lot of information to inform this might be problematic. Ages up to 4 are observed, however, and a 6+ or 7+ group might be more appropriate.

Increasing M is still going to be a problem. It was asked whether it is possible that the survey is not covering the full range of the stock.

The increase in total mortality and relative F shown for the RV survey data are convincing support that M has increased and is high.

There might not be enough information to use an age structured model.

The random walk run looks similar to the VPA runs. The difference with the VPA is that it uses a time varying M. If the model starts at M=0.4, it takes a while to drop down to M=0.2 and then to increase again. If the model starts at M=0.2, it goes up more quickly and then decreases at the end to account for increasing older aged fish in the population. This model does not fit the survey very well; it needs more flexibility (change the Mdevs). If the model starts at M=0.2, it may remain more consistent through the earlier years until the 1993 period. It would be useful to

see the diagnostics first before more work is done on this. It may never fit well. If the same M is used for all ages, then quick changes in M might be expected based on the changing proportion of ages. The number of nodes can be set to match the number of age groups. It was recommended that the model be started with M at 0.2, 0.4 and 0.6, for comparison.

A random walk M could also be attempted on the short time series. If M walks quickly to some value, then it was recommended that this value of M also be used as a starting value.

Upon further investigation, it was noted that the random walk did not work very well with a more reasonable q. It appeared to only work using a uniform q, and it did not like other values of M. The short time series also ran better with fewer nodes.

Virtual Population Analysis (VPA) Model

Working Paper: How Many Silver Hake are There and What Proportion Die Each Year? CSA Working Paper 2012/66.

D. Clark

Presentation Highlights

Assumptions used in this model are that there has to be more silver hake in 4VWX than are caught, it is unlikely that the RV survey has a q higher than 1 (US net catches better than ours), and there is no good reason for q to have changed over time in an extreme manner.

Everything points to Z being high and M as high (close to 1).

All catch is within strata 461 and 471. These two strata account for 7-30% of the summer survey catch and 3-18% of the winter survey catch. Even if all silver hake are caught in the basins, it is still not likely to be more than 30% of the population.

Males live fast and die. There are almost no males above age 5.

The VPA shows a domed partial recruitment curve, which is expected given the location of fishery and the use of a grate. The partial recruitment curve used to be flat topped.

Model variations included:

- Basic long-term: M=0.4; q for age 6 is 1.9 and age 7 is 4.1.
- Basic short term: 1993-present; M=0.4; q for age 7=13.9.
- Around the corner: q not as high but still continuous increase with age and oldest age > 1.0. The oldest age was estimated for years 1998-2011.
- Around the corner with flattop: survey q is constant for ages 4-7 and q is estimated as 0.8. There was a strong residual pattern over time.
- Long-term estimate of M: M was estimated for 1993 to present for ages 3, 4 and separately for ages 5+. M estimates were >1.
- Short-term high M: indices used for 1993-present; M=0.4 for age 1, 2; M=0.7 for ages 3, 4; M=1 for ages 5-9; q is flat-topped from age 3 at approximately 0.5. There is no pattern in the residuals, but this could just be due to the short time series. The parameter estimates are not entirely satisfactory. There is a strong bias adjustment. The biomass estimates are not too bad. Given the differences in M between males and females, the model may not be very predictive but might provide reasonable direction over short term. A retrospective was not run.

65% of the catch (2002-2011) is from ages 1 and 2; therefore, an analysis using a 3-year average is unlikely to be helpful. No ages were available from the 2012 survey, although ages 1

and 2+ could be estimated from length data. Projections would be fairly meaningless and not much different from using the q adjusted survey indices.

Discussion

Is the high point in 1982 influential? Not in the VPA – only the catch is influencing the model back then. The value could be weighted so that it is not influential.

Any convergence issues with short time series? No, but VPA will almost always work.

It appears that the sexes should be split. There are varying M patterns. Next year will pretty much be a female year class.

The fishery is mostly catching females, as 60% of the catch is female. Females recruit into the fishery as age 1s -- earlier than males. Sexed ageing started in about 1999. Length by sex is available going back, so these could potentially be used for standardization. The length composition of the foreign fishery is available. There are no length frequencies for the domestic fishery. What was going on in the basins is not known. Port sampling did not start until 1999.

Separate male and female VPAs might improve precision but will not work in the current period. Perhaps a female only model should be considered. Only enough males are needed to mate with females.

What will be the impact of having mostly females? Do not need many males for good recruitment. The relationship between SSB and recruitment is not known. The current large year class did not come from a strong SSB.

The long time series ends up in the same place as the short time series, that is, about 100,000 t. The model has problems in the earlier years, which sets up a retrospective. Trying different natural mortalities might get rid of the retrospective; however, it is still hard to explain the high landings earlier in the time series.

Concerning assumptions about what's possible with q in relation to swept area, in the summer, the RV survey should not be missing any coastal fish (should not be inshore then). Offshore, do not see them in deeper water. If the population was bigger then, it could have been more vertically distributed and the survey q might have been different. At lower population size, if silver hake are coming up to feed on krill, they may not be going back down to the bottom.

Russians used tickler chains to get them off the bottom. The Polish fleet had success with large mid-water trawl in the offshore (might have been close to the bottom anyway). Fishing gear fishes at 6 m and survey gear fishes at 3 m.

High M might mean older fish have migrated south. Have not seen older fish in the US survey, but consumption is high. Similar dynamics are occurring in the US Southern stock.

What is the ballpark biomass of the US Southern Stock? The survey biomass is a little higher than in 4VWX, but not by much.

Other possible mechanisms include changes in physiological condition and cannibalism by larger females on the males.

Production Model

Working Paper: Silver Hake Framework Assessment: Bayesian State Space Surplus Production Model. CSA Working Paper 2012/64.

A. Cook

Presentation Highlights

Summer survey sampling shows higher levels of predation on silver hake than other seasons in the 1980s (>7000 samples). Predation in the 1980s was higher than in the 1960s or 2000s (greater than 50,000 samples). Silver hake are 7% of diet of grey seal. All of the grey seal diet data are from Sable Island.

The biomass dynamic model is age aggregated. The parameters r and K are modelled. Data requirements are landings, biomass indices (summer RV, spring RV, ITQ) and a standardized catch rate series.

The main effects considered in the standardized catch rate series include year, area, vessel, and period.

The model was fit WinBUGS using three chains and 300,000 iterations.

An initial run using the full time series (1970-2011) gave unreasonable biomass estimates in recent years. Another run used a random walk to let r and K move over time. The final model breaks the data into two time series. Choosing 1993 as the break point did not influence posterior distribution; anything between 1988-1997 could be used. Estimates for r and K were both larger before 1993 than after 1993. Qs have also changed in the RV survey and spring survey.

Model fits fairly well to the RV survey, catch rate series, and spring RV survey. Total biomass has risen to 80,000 t in the recent period. A retrospective analysis shows the model does well until 2005. The year 2004 is problematic. The model both over and underestimates biomass compared to the RV survey in some years. Projections one year ahead and perhaps two years ahead work since 2008. The model ignores changes in age structure or size structure. A delay difference model, which breaks things into stages, might be better able to track these changes. This could be a research recommendation.

Discussion

What could cause K to decline? Productivity has changed and the system cannot support the productivity observed in the past. It might have been expected to go the other way due to declines in silver hake predators (not all of them). Oceanography might also be a factor. A change in condition would also lower K. This does not mean that the stock could not return to a higher K. In the past, the rate of population growth was faster.

Was a prior applied to the precision parameter? This is not standard practice for this type of model. A prior was applied to the standard deviation.

Are the priors the same in the two periods? What is linking the two time periods? These are two separate models joined by the biomass only.

1993 is the year that the spiny dogfish disappeared. Cod also started to disappear then.

It was asked how the transition at the break point was modelled. The response was that biomass was just automatically affected by a new r and K. It was suggested that a more gradual break point might be more appropriate. A random walk was used, but perhaps a sliding window would be more appropriate. A state space model has a memory, so splitting the series is not the same as fitting two separate series.

It was asked whether there is a way to evaluate the influence of the surveys on the biomass estimate. Perhaps the surveys are just adding noise. It was noted that the ITQ survey did not have much influence. Having the catch rate and RV survey together, which are more similar, created greater coherence. The preferred approach was to include all the surveys.

It was asked whether this model provided more information in terms of predictions. Using a different approach, it would be interesting to compare the predictions with the VPA.

The assumptions of this model are simpler than for the VPA. The model provides no greater mechanistic explanation. Biomass is within the confidence interval of the VPA, which provides greater certainty on the assumptions used in the VPA.

The delay difference model would be worth pursuing.

It was asked what the benefit of running the model was beyond just using the survey series. It was suggested that it would smooth out some of the variance.

It was suggested that a Harvest Control Rule is needed to determine what the action would be in response to a change in stock status. The action will depend on the question presented from Ecosystem and Fisheries Management. It was asked whether DFO Science would be asked what the impact of catch is on the biomass (target and limit F).

Surplus production was not estimated from this model. If it was, it could be used to look at the consistency of the surplus production against the biomass.

The fishery is on age 1 silver hake. The survey happens after 60% of the year has gone by and a large chunk of the quota is gone. Without a recruitment equation, it was not clear how was recruitment estimated. Catch rates are informative now, but it may not be appropriate to rely on the ongoing consistency of those vessels into the future.

The model could be re-run every year rather than just reporting the RV survey trend.

It was asked whether catch levels were expected to be relatively constant over the next few years. It was clarified that this is not expected. The main control variable in this model is catch, and projections rely on expected catch. The most recent survey year cannot be included. It is possible to project what the survey would be and then compare to the actual survey results.

The 2012 survey point could be added to the time series (and would be in the assessment).

Model Selection

It was decided that the production model is preferred because of the simplification of the assumptions and no ageing is required between years. This does not mean discontinuing the ageing program. The ageing information should be used when it is available (but it's not right now).

The most recent survey year cannot be used in the VPA. Using the most survey results was felt to be more important than additional age information.

It was decided that the production model is also preferred as it enables projections to be made for the next few years. However, potential for changes in productivity would need to be evaluated.

The surplus production model should be used to describe current status. Some VPA runs should be done for comparison, but the MSY or B_{MSY} calculations are not needed, just the biomass projections. The F that the VPA uses is only relevant for one age. Recent trends in exploitation could be compared.

SUMMARY OF DAY ONE

T. Worcester

The basis for the assessment area was reviewed and reconfirmed as the RV survey strata on the Scotian Shelf (440-483). There was a suggestion to look for any difference in the timing of maturity between the Scotian Shelf and Bay of Fundy areas.

The data inputs were reviewed again. The new standardized catch rate series was presented and people were asked to comment. Natural mortality was discussed. Everything points to increasing M in recent time period, with current high levels of M, particularly on older male silver hake. As with cod and other species with increasing M, hypotheses include increased predation/consumption by other fish and seals and changes in condition (related to a number of factors). For silver hake, there is also the possibility of increasing cannibalism by larger females on smaller males. There was no consensus about whether there should be any concern about the possibility of incidental mortality from mesh/grate.

A question was raised as to whether there had been a shift in the size structure in the basins over time. Histograms of length frequencies for each basin could be constructed.

Three possible modeling approaches were explored: ISCAM model, VPA, and a surplus production model. Two of these are aged based and none account for sexual dimorphism in silver hake (and likely that next year will be a primarily female only year class).

The ISCAM and VPA models both used the summer RV survey and fisheries information (mostly), including the ageing information. The surplus production model used the standardized CPUE index, summer and spring RV surveys and ITQ survey (though they did not add much, i.e. it is not dependent on these), but it did not use the ageing information.

All models explored use of RV survey data from 1977-2011 and looked at influence of a split at 1993 or a starting point of 1993. The split or short time series seem to work best.

The ISCAM and a VPA model explored fixed versus varying M. Varying M worked better, as M appears to have changed over time. Surplus production does not need M, but incorporates this into changes in r and K.

ISCAM runs tended to have higher qs, which would need some explanation. VPA did gymnastics to keep survey qs lower/reasonable. It needed high M and short time series to do this. Surplus production indicates change in qs (0.43 for summer RV at present).

Current biomass in the ISCAM model ranged from approximately 60,000 to 250,000 depending on the run. The preferred VPA generated a biomass of approximately 110,000 t. Surplus production biomass generated a biomass of approximately 70,000-80,000 t. All models indicate lower exploitation at present than in the past.

Projections from the ISCAM model were not discussed as it was not quite a working model yet. Projections from the VPA model were not considered to be useful. Projections could be used from the surplus production model.

With truncated age structure and a fishery primarily targeting young fish, it is not clear that ageing information provides much additional value.

Long-term recommendations are to explore a delay difference model and a female only model (or split sex model).

Homework from Day One

D. Themelis reported on trying a random walk with the basic ISCAM model (entire series) but could not get it converge with an M other than 0.45. With the short series, the prior on q had to

be changed. The model had a bad retrospective. Different selectivities were attempted, but there is still a need to find a selectivity that works.

L. Alade reported on trying to run the data in ASAP (an age structured assessment model), which also produced bad retrospectives. He had the same problems when doing the US silver hake assessment. He used an M of 0.4.

Recommendation: Include some aspects of the ISCAM modeling into the Data Inputs Research Document. Only include a summary of what was attempted and perhaps some diagnostics from a single run to explain why it was not simple to get it to work. Include some recommendations on what should be attempted in the future as well.

A. Cook reported that the state space model does have a memory and that it matters how the transition is modelled. He removed the spring and ITQ surveys. When the survey indices are removed, more of the noise in the individual surveys is captured. With a truncated series, the biomass declined slightly to approximately 70,000 t, and with only the RV survey biomass, declined closer to 90,000 t. B_{MSY} = 40.8, MSY = 14.3, F_{MSY} = 0.36. The recommendation is to start at 1993. Using the time series all the way back to 1977 requires better modeling of the transition. There was a suggestion to include the catch rate series, but it would have to be examined each year.

There was discussion about process and observation error. Process error dropped when both indices were included. Observation error dropped a little but not much. Using both indices puts more emphasis on the process than on the RV survey. The indices could be weighted, but this complicates it.

CANDIDATE BIOMASS REFERENCE POINTS

H. Stone

Presentation Highlights

A seven year period of high productivity (1982-1988) was used to calculate B_{MSY}. This is outside the period requiring the survey conversion factor. The geometric mean biomass for that period is 58,000 t (53,000 or 49,000 t). The Limit Reference Point (40% B_{MSY}) would be 23,075 t, and the Upper Stock Reference Point (80% B_{MSY}) would be 46,149 t. The stock has been above the USR for the last couple of years.

Discussion

It was asked if the influence of the highest point was examined. The high point does not make a lot of difference.

Given the fishery on small fish, there is limited capacity for a warning signal, which makes setting reference points for this stock difficult. In the years when the stock was below the reference point, no one was having trouble catching it and only a small portion of the stock was targeted.

The 7-year period would not be considered a stable period. It is important to discuss what window (timeframe) should be used.

The consequences of fishing outside of the basins was discussed. Population composition can be quite different depending on location and timing. Fishing in the basins in winter results in a higher proportion of older fish. However, if the grate is used, the big fish canno be caught. Biomass on the edge is lower than in the basins. Generally, the fishery only goes to the edge in the summer when silver hake run out of the basins. It's too far to go there unless it's required. It is also hard to avoid swordfish gear there, too.

It was asked if a sensitivity analysis of the reference points could determine how much the current proportion of males/females would have to change to make a difference. This was considered unlikely to make a difference.

It was recommended that the reference points should come from the assessment model.

It was also recommended that the current time period should be used to set the reference points; biomass levels are three times lower than in the earlier time period. The stock could return to levels of that time period, but it was recommended that the current period be used for consistency with the assessment.

It was asked if numbers should be used instead of weight. This is not required because the change in weight at age may not be significant enough to warrant this. It is not just condition related.

It was asked whether two sets of reference points could be provided (based on short and long time series). This was considered possible but not necessarily desirable.

It was also suggested that the q from the preferred model could be applied to the survey to generate a biomass trend, with reference points generated from this.

The consensus was to use the reference points generated from the assessment model, along with a good rationale for doing so.

FRAMEWORK ASSUMPTIONS / MECHANISMS

The rationale for splitting the time series at 1993:

- Start of the Canadian only fishery (1998, but mostly Canadian 1995).
- Change in gear (mesh and grate) in 1993.
- Truncated age structure (first year with no age 6+: 1994).
- Focusing the fishing activity in the basins.

The surplus production model indicates change in r and K. More explanation of these changes should be included.

The surplus production model sets a sensible harvest level for the entire stock area. Within a management context, this needs to be rationalized given the fishery takes places within a limited area. In contrast, the VPA uses a partial requirement that takes this into account, so the projections were not as good. It assumes there are fish out there that canno be caught.

Sex ratio and age structure issues: the production model canno respond quickly to recruitment or changes in age/sex structure. However, it is also not as strongly influenced by year effects as age based models.

It will be interesting to see what happens with the 2009 year class. This year class can be observed in the commercial catch length frequencies and in the survey.

REVIEWER COMMENTS

The reviewer felt that the modeling work done to date was heading in the right direction. He felt that the complexities of the data structure and modeling were such that further expansion in the age structure would be required to make this ageing information more useful. A simplistic approach might be the way to go in the meantime. In terms of reference points, he felt that having both options (i.e., based on long-term and shorter-term conditions) available might be worth considering.

He noted that adding consumption into the model used for the US silver hake assessment improved the model diagnostics. However, a long time series of information was available that could be used. Predators were included as a separate fleet in terms of removals. The model was used to estimate an M2. The US assessment had selectivity issues as well, and there was some difficulty in deciding whether it should be dome shaped or flat-top.

RECOMMENDATIONS FOR SCIENCE ADVISORY REPORT

Fishery

- Separate catch into basin/slope as before.
- Include the catch at age.
- Include CPUE index.
- Observer coverage (should be identified as sufficient rather than providing the actual numbers)

Stock Status and Trends

- Biomass trend in the RV survey, and catch at age.
- All ages, 2+, and female 2+ biomass.
- Recruitment: Age 1 index.
- No relative F or total mortality figure.
- Fulton's K condition figure.
- Length at age for combined sexes.

Model Results

- Biomass, exploitation.
- Reference points.
- Projections for 1 year. Assume calendar year caught for 2012. 2013 catch to be provided by Resource Management (e.g., average of something reasonable). Include probability of exceeding reference points.

Ecosystem Considerations

- Bycatch, predators/consumption, fishery footprint

Appendix

- Example of what would be produced in the interim years between assessments.

INTER-FRAMEWORK REVIEW ACTIVITIES

The next framework should be conducted when there is: a better understanding of changes in natural mortality; increasing age structure; a change in stock structure; approach of a reference point; or a better model working.

In 5 years, the assessment team should determine whether any of these conditions have been met.

PART 3: ASSESSMENT (DECEMBER 11, 2012)

INTRODUCTION

The chair of the meeting, T. Worcester, Coordinator for the Centre for Science Advice in the Maritimes Region, welcomed everyone and thanked them for coming to the DFO Science Peer Review of the 2012 Assessment for 4VWX Silver Hake.

As described in the Terms of Reference (Appendix 1), this third meeting was to review the completed assessment, including the status of 4VWX silver hake using the agreed to assessment approach and up-to-date fisheries and survey information. In addition, the consequences of various harvest levels during the 2013/2014 fishery on stock abundance and exploitation would be reviewed.

Participants (Appendix 2c) were encouraged to ask questions of clarifications and to participate actively in the discussion. It was explained that the meetings would operate by consensus, where possible.

The Agenda (Appendix 3c) was reviewed and nothing further was added.

FISHERY AND SURVEY RESULTS

D. Themelis

Presentation Highlights

Catches reported by at-sea observers from 1977-2011 were provided. The fishery has moved from the shelf edge to the basins more recently. The TAC has been set at 15,000 t since 2003. Landings are at a relatively low level compared to earlier in the time series: 8,400 t in 2010 and 9,200 t in 2011.

The fishery caught mainly ages 3-4 in the 1970s and 1980s. There has been an increasing proportion of age 1 and 2 in the catch since then.

Fishery weights at age show a declining trend from 1977 through 2011.

A standardized catch rate series was calculated using commercial fishery landings and effort data from 1999-2011 for five vessels broken into two seasonal periods.

The RV survey biomass index and age composition in the RV survey show a high proportion of ages 1-3. There are few fish older than age 7 but more ages 4-6 than earlier.

The abundance of age 1 in the RV survey was used as an estimate of recruitment. Abundance has been variable but above the long term average for the past three years. The 2009 year class is the largest in the time series.

Condition factor is really low.

Mean length at age shows a general decline over time, with some recent increases.

Discussion

It was asked why the figure of commercial catches in 1977-1980 shows landings in the basins which do not show up in the catch. It was explained that there was some experimental fishery in 1977-8 in the basins. The foreign fleet could fish inshore if they had an observer on board or were fishing for squid.

RV length frequencies were investigated year by year as an indication of stock definition. Brown's Bank, which is an area that shows more similarity to the Bay of Fundy than to the

Scotian Shelf in 2012, was interesting, but it will not make a big change to the stock area. It does suggest that the strata boundaries used for cod/haddock might be more in line with silver hake. Big fish are never found in the Bay of Fundy.

It was asked whether the silver hake from the Bay of Fundy are likely to go onto the Scotian Shelf or into the Gulf of Maine. It is unknown where large fish go in the Gulf.

The 2009 year class is strong but difficult to see in the figure showing commercial catch at age because numerical bubble plots are used rather than proportional bubbles. It was recommended to use proportions such as used in the Bayesian modeling document.

Recommendations

If there is a historical data set for the basin, compare this to the model results.

Explore the differences in length frequencies for the different areas more closely, for example, by looking at spring surveys (6 years). Note: This was done, and the comparisons in length frequencies between the slope and basin strata are contained in the Research Document. Such a small proportion of fish are in the Bay of Fundy and on Brown's Bank that it does not make much difference. It was suggested to add some text about this in the sources of uncertainty.

MODEL RESULTS

Working Paper: Bayesian State Space Biomass Dynamics Modeling and Assessment of 4VWX Silver Hake 1993-2012. CSA Working Paper 2012/69.

A. Cook

Presentation Highlights

The biomass dynamics model was described including the data inputs. The parameter estimates were shown, with changes that indicated that there was information to inform the analysis. The fit between model estimated biomass and the RV survey was good.

A surplus production analysis was added. In earlier years, a downward cycling (clockwise hook cycle) was observed and recruitment was low. In recent years, there is more stable recruitment and the cycle is coming back around.

The model was fit to the full time series to project forward and also used to estimate biomass. The model is under projecting biomass for the last couple of years. This is partially explained by lags in the aggregate model.

In terms of reference points, process error was included to account for stochasticity in the environment. F and B phase plots were shown. F has always been below F_{MSY}, and the biomass has mostly been above B_{MSY} except for a few earlier years.

Landings scenarios were explored by applying the mean of the last 3 years, and then for April-June, using various landings scenarios (and proportion generally caught within that timeframe). The probabilities of dropping below 80% and 40% B_{MSY} were all less than 0.1.

Habitat associations were also investigated using the method of Perry and Smith (1994). The distribution of sampling of any environment variable can be described as an accumulation curve. If the sampling is weighted by catch, in some years, see it go up, which provides an idea of habitat preference. This was conducted for all years, for small (<20 cm) and large fish (>20 cm), in terms of depth, salinity and temperature. Small silver hake are caught mostly between 125-155 m. Their distribution is closely related to temperature; they are always found at warmer temperatures than the mean survey.

Catch rates and depths were also compared. Catch rates are higher when fish are at shallower depths. There was no relationship between area occupied and catch rate.

The relationship between Fulton's K and temperature was investigated. A strong correlation was found between Fulton's K anomalies and temperature anomalies with some annual lag effects. There is a relationship between environmental condition, and recruitment and female condition.

The stock is at the highest biomass estimated for the years 1993-2012. It increased in the last ten years and has been high and relatively stable for the last 4 years. Fishing mortality has decreased over the past 5 years and is currently at the lowest level in the last twenty years.

It was suggested that age or stage disaggregated models should be explored for future assessments.

Discussion

Information presented at the Data Inputs meeting indicated that there was a declining trend in Fulton's K. It was clarified that the decline is mostly in larger fish and earlier in the time series. When the condition is separated out by size and sex, and the scale is changed, the decline is not very strong.

Condition anomalies are just relative. It might be helpful to work out absolute threshold – relative index.

It was asked what was meant by 'windsorizing.' In any given year, there will be a range of catch rates. Each one influences the mean estimate. If there is a year with one highly influencing point, it can be downweighted or taken out. Decreasing it to the next plausible point is called windsorizing.

The threshold for windsorizing was 40% of the stratified mean, that is, a point greater than 40% for the time series. There was no basis for choosing this threshold.

It was asked how much influence windsorizing had on the model fit. It was explained that there was little effect overall in terms of biomass estimates, but it improved the retrospective for the 2004 year.

It was clarified that survey standard error was not used for downweighting, although this approach was considered. It would be good to compare these methods.

Projections are only going through to the middle of 2013. However, they are needed to cover the full 2013/2014 fishery. This requires making a lot of assumptions. The further forward projections are made, the less certain they are. However, a one year projection that only covers 30% of the quota year was not considered to be very useful for management. It was also unclear how these results would be updated each year. However, it was felt that it would be difficult to go beyond one year of projections without specifying the stock recruitment relationship. The approach seems to provide a better sense of how appropriately the TAC had been set for the previous year than advice on how to set the TAC for the coming year, although it does provide advice on a few extra months. It was suggested that, in the future, perhaps the model could be used as an evaluation of the HCR.

For evaluation of projections, a year was chopped off and then it was projected forward. Projections were pessimistic for the past 4 years. Even with windsorizing, 2004 is a big year. It was clarified that it is the model fit that is projected, not the survey. It was suggested that the model projections could be evaluated against the survey results. If an evaluation is done of how well the model predicts the survey 2 years ahead, this could indicate how far ahead projections can be made with some reliability.

If you look at the scenarios, it seems difficult to do much damage to the resource, but things can change quickly within a year. There is more than the 2009 year class in the fishery. They do move through the fishery fairly quickly.

Projections using the VPA estimated about 16,000 t. This was due to domed partial recruitment (some of the large year class are already moving out of the fishery), but also have to assume incoming recruitment. This big year class will be a bit of a test. The fishery may or may not catch them. This model will not pick up on the domed recruitment.

Different landings scenarios could be integrated into the F_{MSY}/B_{MSY} plot.

It was asked how recruitment is addressed in the model. It was clarified that recruitment is a component of r. The approach assumes mean recruitment.

It was clarified that the survey does not catch young of the year well. Silver hake are spawned in September, so they can be less than 1 year old in the survey.

It was clarified that survey biomass is not q adjusted.

Did you do some sensitivity analysis to see the impact of a bigger range on posterior distribution? Sensitivity analyses showed that there was some degree of sensitivity but no change in trends. The posterior does cover the range.

Comparing the k values with the current assessment results shows that biomass is very close to carrying capacity, which is confusing given pre-1993 data. Carrying capacity was quite different then, so the fishery is either fishing a different component or there is more influx/outflow than accounted for. That is why k is estimated just for this time period.

Methods for modeling across the transition between the time periods should be explored in the future. Presumably the transition is not abrupt (knife edge).

Clarification was sought on historical values of r. Historical values were slightly higher than current values. The VPA will only fit assuming a high natural mortality in the recent period. This is consistent with the hypothesis of a regime shift.

It was asked whether any alternative estimates of MSY were provided. These could be obtained from the ASAP model.

In the retrospective plot, the red line does seem to be generally below the rest of the lines except for a few years. This indicates consistent underestimation by the model.

Recommendations

Project to the end of the fishing year with increasing error bounds.

Include the historical context of change in the productivity regime and changes in r and K.

Include a disclaimer on yield at F_{MSY}, that if yield is contained within the basins, it would be impossible to catch the TAC. There are limitations on how much silver hake can be caught in a year within the basins. Reference points are for the whole area, but the fishery is contained within the basins in most years.

Project biomass to the end of June 2013 with 50% confidence intervals. Some of the catch scenarios can be eliminated. Leave catch and status quo, + and – 20%. Keep 12, 15, and 18. Get rid of 12.75, 17.25. Provide a caveat around F_{MSY}.

Include table to end of fishing year, March 2014.

Most of the adults are female; therefore, reference points would not be lower if only the females are considered. Original derivation of r was abundance converted to weight. A 50/50 sex ratio

might fit with the assumptions. It was suggested that these be called proposed reference points, i.e. "the default values of 80 and 40% B_{MSY} are proposed as the limit reference point and upper stock reference."

REVIEW OF SCIENCE ADVISORY REPORT

Title

4VWX versus Scotian Shelf? The assessment does include some catch in NAFO Division 4X and incidental catch in 4V.

Context

Were the fishery restricted or did it just fish on the edge? It was restricted, but there were many exemptions.

Figure 1. Use A. Cook's map showing the red boundary of the assessment unit.

Biology

Remove mention of 4VWX in the self-reproducing area paragraph.

Combine small and large fish and say temperature preference from 5 – 10 °C.

Add mention of grey seals as predators in a separate sentence – from Sable Island (Bowen and Harrison 2007) seasonal. Add this to Research Document also.

Fishery

Remove TAC from the first sentence.

Clarification that 2000-2004 shows no foreign landings but there was foreign fishing under Canadian quota.

Fix Figure 2.

For Figure 3, show proportion instead (makes it easier to read). Add line when grate came in.

Delete weights at age text and figure.

Remove the CPUE section.

"This series is considered to reflect a recent increasing trend in relative abundance, though there would have been a learning curve in the early years."

Add fishery footprint map. Make sure depth is included.

RV Survey

Add sentence referencing Figure 1 at the beginning of the section.

Fix Figure 6 caption.

Redo Figure 7 in terms of proportions.

Assessment Results

Include table of mean biomass estimates in the Research Document, and add values to the Science Advisory Report.

For reference points, add new text.

Include projections for 1 year. Assume calendar year catch for 2012. 2013 catch to be provided by Resource Management (e.g. average of something reasonable). Include probability of exceeding reference points.

The sensitivity of projections would be more useful than the retrospective analysis. The sensitivity (box) plot is better than Figure 12 (for one and two years ahead).

Sources of Uncertainty

Note that there is very little information to base projections on.

There are still some outstanding questions about the stock boundary.

INTERIM REPORTING

Include:

- Landings from the previous year.
- Survey biomass (reference the RV survey trends report and make sure they are consistent).
- Recruitment index (age 1s from the RV survey).
- Harvest Control Rule: track trajectory for last 3 years.
- Text description of biomass and exploitation in relation to reference points.
- Projection for the next year? Maybe not needed or include in the Harvest Control Rule.

Draft an example of what might be provided as an Appendix to the Science Advisory Report or the proceedings, if possible.

REFERENCES

DFO. 2010. Silver Hake on the Scotian Shelf (Divisions 4VWX). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 20010/007.

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Halliday, R.G., and Cooper, C.G. 1997. The Effect of Codend Separator Grates on Silver Hake Otter Trawl Catch Rate. NAFO SCR Doc. 97/51 Serial No. N2885.

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Northeast Fisheries Science Center (NEFSC). 2010. 51st Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dept. Commerce. Northeast Fish. Sci. Cent. Ref. Doc. 11-01: 70 p.

Perry, R.I., and Smith, S.J. 1994. Identifying Habitat Associations of Marine Fishes Using Survey Data: An Application to the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 51: 589-602.

Phoel, W.C., Eckhardt, R.A., Sawar Jahangir, Z.M.G., Lovgren, J.R., and Amaru, W.H. 2001. Preliminary Studies on Silver Hake (*Merluccius bilinearis*) Population Identification Using Microsatellite DNA Along the Northeastern US Coast and Their Abundance Correlated with Bottom Water Temperatures in the Middle Atlantic Bight. Oceans 2001. MTS/IEEE Conference and Exhibition 3: 1596-1601.

Showell, M.A., Young, G., and Fowler, G.M. 2010. Assessment of the Scotian Shelf Silver Hake Population Through 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/072.

APPENDIX 1. TERMS OF REFERENCE

Review of the Framework and Assessment for 4VWX Silver Hake

Regional Peer Review – Maritimes Region
Part 1 - Data Inputs: May 30-31, 2012 (Dartmouth, NS)
Part 2 - Modelling: Nov. 15-16, 2012 (Dartmouth, NS)
Part 3 - Assessment: December 11, 2012 (Dartmouth, NS)

Chairperson: Tana Worcester

Terms of Reference

Context

Silver hake is a bottom dwelling member of the gadoid family, found from Cape Hatteras to the Grand Banks and Gulf of St. Lawrence. A population of silver hake occurs on the Scotian Shelf (Div. 4VWX). The last assessment of the status of Scotian Shelf silver hake was conducted in 2009 (DFO 2010). A new assessment has been requested by DFO Resource Management to provide harvest advice in support of the fishery in the Maritimes Region. DFO Science has been asked to review and evaluate the biological and fishery information on 4VWX silver hake status and characterize the uncertainty of the results; specifically, provide information on distribution, biomass estimates, length and age composition, condition, highlighting any trends over the long-term (length of assessment), mid-term (past 15 years), and most recent period (5 years). Given known problems with the assessment model for this stock (as described in the 2009 assessment), it was determined that a new framework was required. The review of the framework and assessment for 4VWX will be conducted in three parts: review of data inputs, review of the model, and then the assessment.

Objectives

Part 1 – Data Inputs

- Describe the basis of the management unit

- Review fisheries and survey data sources, including
  - Fishery sampling: commercial catch, distribution, length and age composition
  - DFO Research Vessel (RV) survey sampling: survey catch, distribution, length and age composition, condition
  - Industry (ITQ) survey sampling: survey catch, distribution

- Review catch-at-age, including
  - Documentation of past ageing approach
  - New ageing approach using otolith weights

- Review relevant biological and ecological information, including
  - Biology: growth, age, life history, sex, fecundity, natural mortality, spawning location and timing, recruitment
  - Ecosystem information: bycatch, trophic information, temperature, fishery footprint

- Review indices of abundance, including
  - RV survey indices
  - ITQ survey indices
  - CPUE index

Part 2 – Modelling Review

- Determine the methodology to estimate the current state of the stock, including methods for estimating stock size and fishing mortality
- Determine the methodology to characterize stock productivity including reference points for fishing mortality and spawning stock biomass
- Determine forecasting methodology for providing advice on harvest levels
- Provide guidance on inter-framework review activities, including
  - Review procedure and frequency of providing fisheries management advice
  - Review events that would trigger an earlier-than-scheduled assessment

Part 3 – Assessment

- Report on the current status of 4VWX silver hake based on the latest information from fisheries and research surveys, and characterize the uncertainty of results. Specifically, provide information on distribution, biomass estimates, length and age composition, and condition, highlighting any trends over the long-term (length of assessment), mid-term (past 15 years), and most recent period (5 years).
- Evaluate the potential consequences of different harvest levels during the 2013/2014 fishery on stock abundance and exploitation rate.
- Identify appropriate reference points for 4VWX silver hake and evaluate the current status in relation to these reference points.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document(s)

Participation

- DFO Science and Resource Management
- Provincial representatives
- Fishing industry
- Aboriginal communities/organizations
- Other invited experts

References

DFO. 2010. Silver Hake on the Scotian Shelf (Divisions 4VWX). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/007.

APPENDIX 2A. LIST OF PARTICIPANTS: 30-31 MAY 2012

Review of 4VWX Silver Hake Framework: Data Inputs
Maritimes Region Peer Review Process

Hayes Boardroom
Bedford Institute of Oceanography
May 30-31, 2012

PARTICIPANTS

NAME	AFFILIATION
Belliveau, Ray	Charlesville Fisheries Limited / MG < 65 ITQ
Black, Jerry	DFO Maritimes / PED
Boudreau, Cyril	NS Dept. Fisheries & Aquaculture (NSDFA)
Campana, Steve	DFO Maritimes / PED
Claytor, Ross	DFO Maritimes / PED
Comeau, Peter	DFO Maritimes / PED
Cook, Adam	DFO Maritimes / PED
d'Entremont, Alain	Scotia Harvest Seafoods
Docherty, Verna	DFO Maritimes / Res. Mgmt
Floyd, Trevor	DFO Maritimes / CSA
Fowler, Mark	DFO Maritimes / PED
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Perley, Neil	Maliseet Nation Conservation Council (MNCC)
Sameoto, Jessica	DFO Maritimes / PED
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Showell, Mark	DFO Maritimes / PED
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Stone, Heath	DFO Maritimes / SABS
Themelis, Daphne	DFO Maritimes / PED
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Young, Gerry	DFO Maritimes / PED

APPENDIX 2B. LIST OF PARTICIPANTS: 15-16 NOVEMBER 2012

Review of 4VWX Silver Hake Framework: Modelling Review
Maritimes Region Peer Review Process

Hayes Boardroom
Bedford Institute of Oceanography
November 15-16, 2012

PARTICIPANTS

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Alade, Larry	NMFS / USA
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d'Entremont, Alain	Scotia Harvest Seafoods
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Floyd, Trevor	DFO Maritimes / CSA
Fowler, Mark	DFO Maritimes / PED
Hurley, Peter	DFO Maritimes / PED
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APPENDIX 2C. LIST OF PARTICIPANTS: 11 DECEMBER 2012

Review of 4VWX Silver Hake Assessment
Maritimes Regional Peer Review Process

Needler Boardroom
Bedford Institute of Oceanography, Dartmouth, NS

11 December 2012

PARTICIPANTS

Participant	Affiliation
Belliveau, Ray	Charlesville Fisheries Limited / MG < 65 ITQ
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Young, Gerry	DFO Maritimes / Population Ecology

APPENDIX 3A. AGENDA: 30-31 MAY 2012

Review of the Framework and Assessment for 4VWX Silver Hake : Data Inputs

Regional Peer Review – Maritimes Region

30-31 May 2012
Hayes Boardroom, BIO
Dartmouth, NS

DRAFT AGENDA

30 May 2012 – Wednesday

9:00-9:15 Welcome and Introductions

9:15-9:30 Review of Management Unit

9:30-10:30 Review of Data Sources
- Fishery sampling - commercial catch, distribution, length and age composition
- RV survey sampling - survey catch, distribution, length and age composition, condition
- ITQ survey sampling - survey catch, distribution

10:30-11:00 Break

11:00-12:00 Review of Ageing Methods and Catch at Age

12:00-1:00 Lunch (not provided)

1:00-2:30 Review of Abundance Indices

2:30-3:00 Break

3:00-4:00 Review of Biological and Ecological Information

4:00-4:30 Discussion

31 May 2012 – Thursday

9:00-9:15 Review of Previous Day

9:15-10:30 Discussion of Outstanding Items from Day One

10:30-11:00 Break

11:00-12:00 Next Steps for Completion of Framework and Assessment

APPENDIX 3B. AGENDA: 15-16 NOVEMBER 2012

Review of the Framework and Assessment for 4VWX Silver Hake : Modeling Review

Regional Peer Review – Maritimes Region

15-16 November 2012
Hayes Boardroom, BIO
Dartmouth, NS

DRAFT AGENDA

15 November 2012 – Thursday

9:00-9:15	Welcome and Introductions
9:15-9:30	Review of Management Unit
9:30-10:30	Review of Data Sources and Assumptions
10:30-11:00	Break
11:00-12:00	Review of Data Sources and Assumptions (con.)
12:00-1:00	Lunch (not provided)
1:00-2:30	Review of Proposed Assessment Modeling Approach
2:30-3:00	Break
3:00-5:00	Review of Proposed Assessment Modeling Approach (con.)

16 November 2012 – Friday

9:00-9:15	Review of Previous Day
9:15-10:30	Reference Points and Indices of Stock Status
10:30-11:00	Break
11:00-12:00	Inter-Framework Review Activities: monitoring, assessment format and frequency, definition of exceptional circumstances, research recommendations
12:00-1:00	Lunch (not provided)
1:00-end	Next Steps for Completion of Framework and Assessment

APPENDIX 3C. AGENDA: DECEMBER 11, 2012

Review of the Framework and Assessment for 4VWX Silver Hake: Part 3 – Assessment.

Regional Peer Review – Maritimes Region

11 December 2012
Needler Boardroom, Bedford Institute of Oceanography
Dartmouth, Nova Scotia

DRAFT AGENDA

11 December 2012 – Tuesday

9:00-9:15	Introduction
9:15-10:15	Presentation of 4VWX Silver Hake Assessment
10:45-11:00	Break
11:00-12:00	Review of Assessment
12:00-1:00	Lunch (not provided)
1:00-1:30	Discussion of candidate Harvest Control Rule and interim reporting
1:30-end	Review of SAR